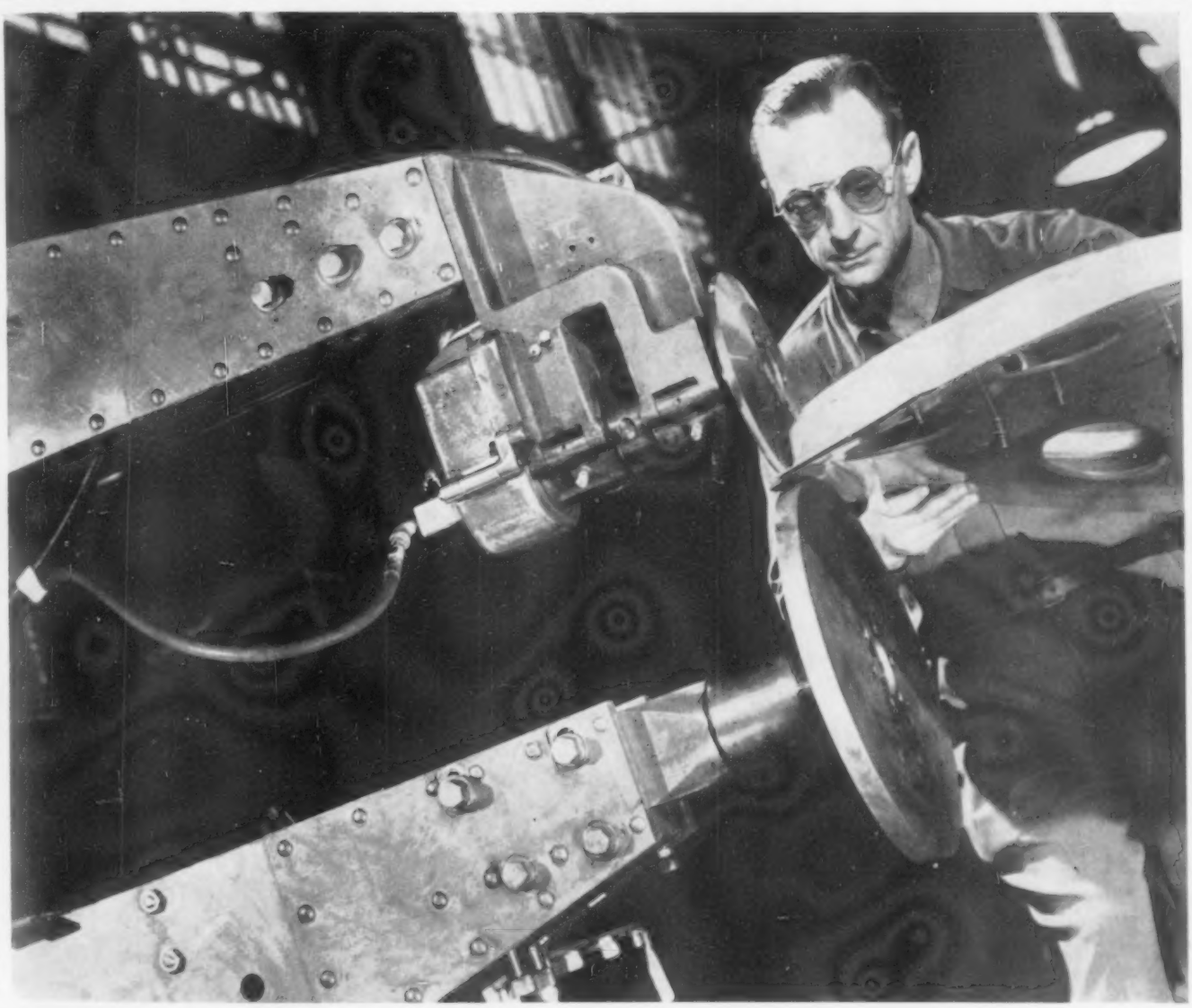
FEBRUARY 1944

The WELDING Journal



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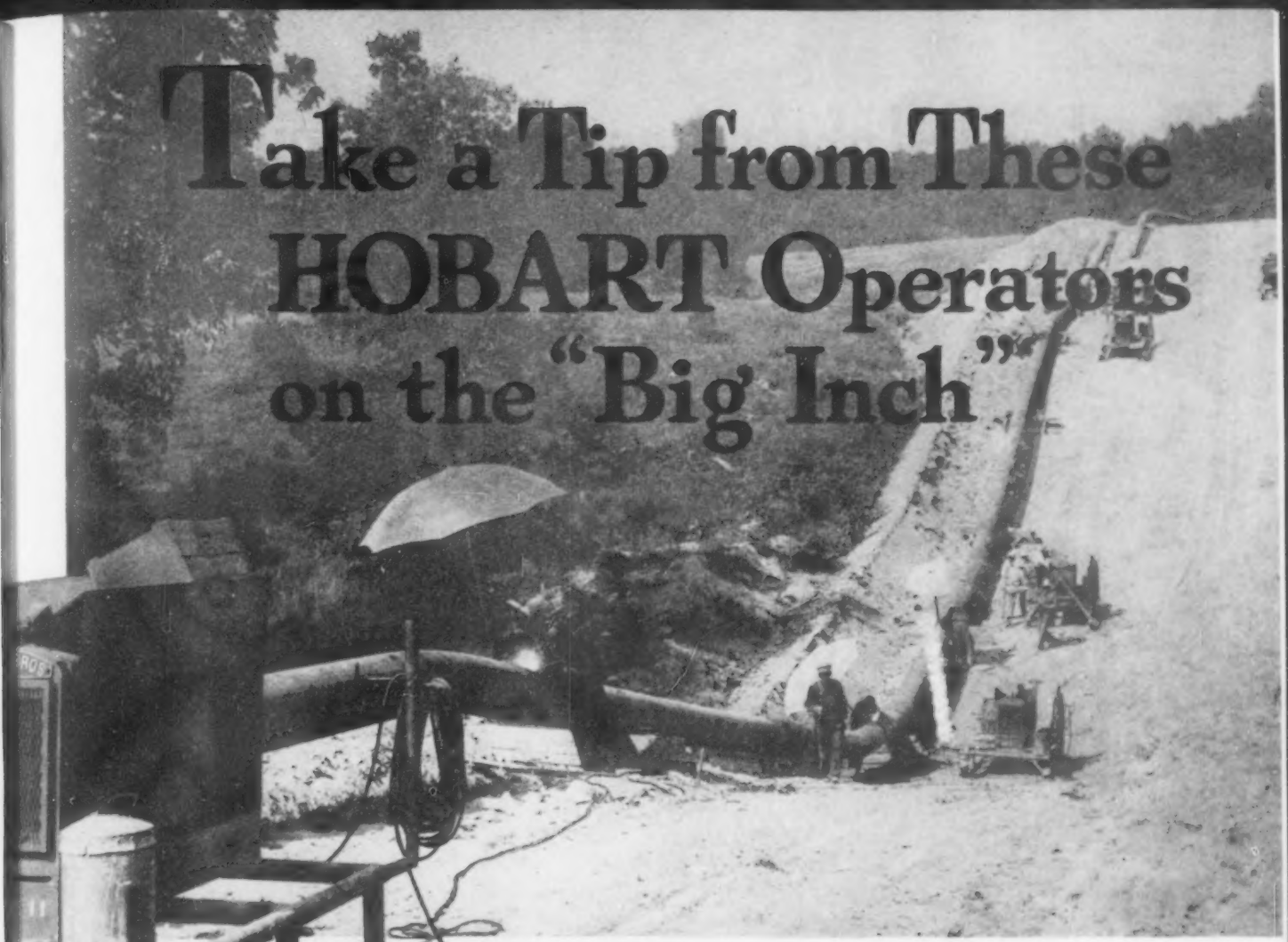

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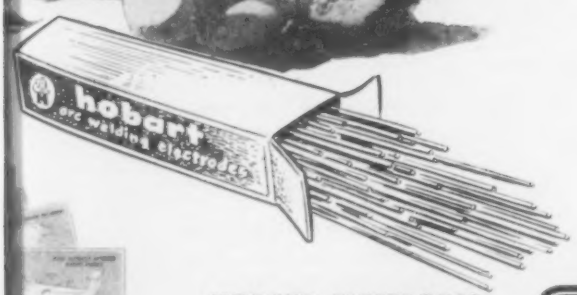

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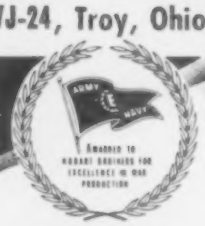

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W. SPRARAGEN, Editor

February 1944

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Seam Welding an Aircraft Assembly Made of Alclad Sheet and Other Aluminum Parts. *Courtesy Aluminum Co. of America*

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Prefabrication of Welded Ships in a Structural Steel Fabricating Plant*

By E. T. Blix and J. C. Arntzen†

IN PREFABRICATING welded ship sections in a structural steel fabricating plant, the first problem is not one of shop procedure or welding technique, but has to do with the language used in the shipbuilding industry. Unless all of the members of this audience have had experience in ship construction, I doubt very much whether I would get a 100% correct answer to the question of differentiating between sheer and camber, or between a knuckle and a chine line, or if many of you could point out the location of a strake or the skeg on a vessel. If you men are not in a position to answer these questions, or if you would be surprised to learn that a "floor" in ship terminology is a vertical girder instead of a horizontal member, you can imagine the difficulty our workmen would have in interpreting the information given to us by the naval architects.

Our company did not enter into this shipbuilding program as a beginner in welded work in the welded structural steel field. As far back as 1925, our vice-president, Mr. G. A. Caldwell, was a member of the Structural Steel Welding Research Committee of the AMERICAN WELDING SOCIETY. In these early days, one of the first welded products made by our company was welded, curved, chord trusses. In order to prove to the doubting engineers and the public that these trusses would carry the loads for which they were designed, we tested each type of truss by actually loading the top chord by means of air cylinders, spaced about 3-ft. centers, producing for all practical purposes a uniform loading. The pressure was controlled by the amount of air used, thereby producing any desired roof loading.

* Presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Chief Engineer and Assistant Chief Engineer, respectively, Mississippi Valley Structural Steel Co., Melrose Park, Ill.

Fig. 1—Tank Landing Craft, Hull Stern Section, Being Assembled in the Jig

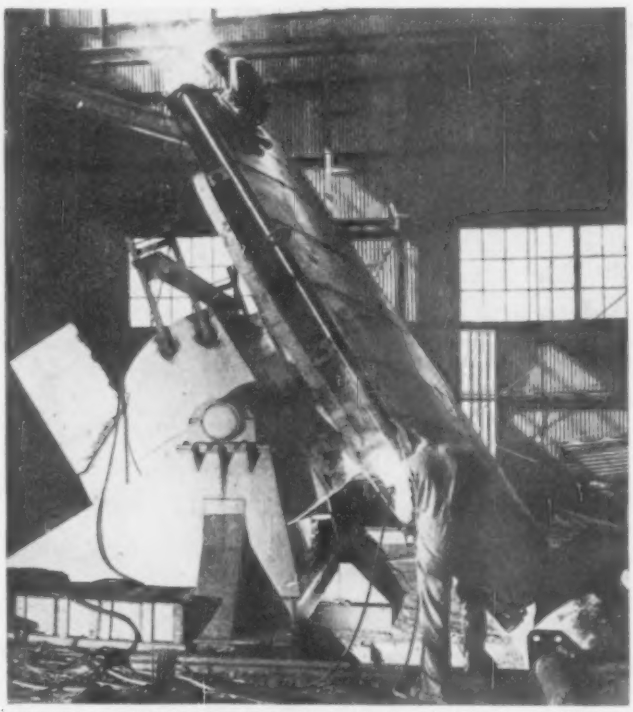

Fig. 2—Tank Landing Craft, Ramp Being Welded on a 20-Ton Capacity Positioner

As early as 1927, when welding for buildings was not generally accepted, our Chicago District plant at Melrose Park was largely built of welded construction and the engineering magazines at that time featured articles of this construction.

During the Century of Progress at Chicago, we were one of the sponsors and participating contractors of the Sky Ride. Largely through the efforts of our engineers, working with the design engineers, this structure was about 75% shop welded. At that time we used bare electrodes.

In the intervening years, we have built a large number of welded projects, such as pile drivers, gantry cranes machinery bases and miscellaneous buildings.

Since this country started its Preparedness Program, and especially after Pearl Harbor, our company has been actively engaged in shipbuilding work. For the Navy, we have prefabricated sections in our fabricating plants and assembled these sections into complete

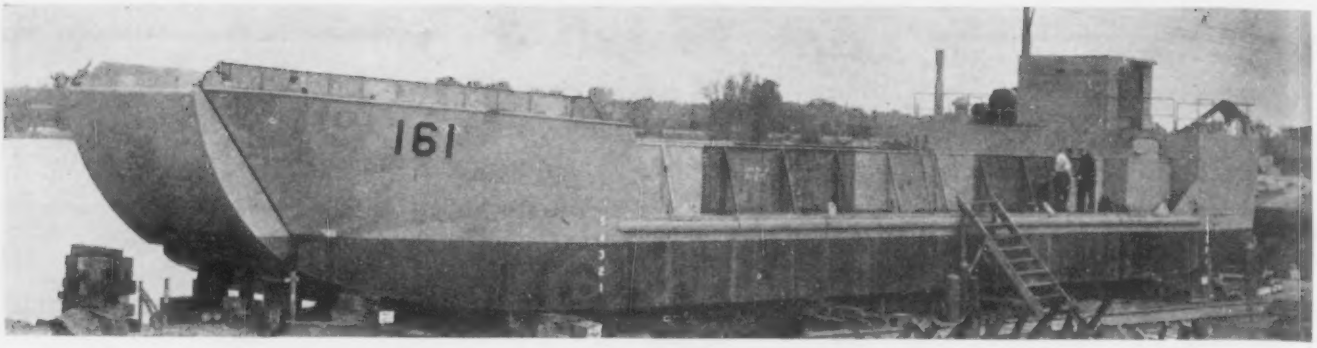

Fig. 3—Tank Landing Craft, Assembly on Ways Ready for Launching

invasion barges and dry docks, and in addition, we have been a subcontractor of the Chicago Bridge and Iron Co. on drydock sections. For the Maritime Commission, we have prefabricated ship sections for corvettes, which were shipped to the Walter Butler Shipbuilders, Inc. For the Army, we are fabricating ship sections for Army supply vessels, which are being shipped to the prime contractor, Higgins Industries, Inc., at New Orleans.

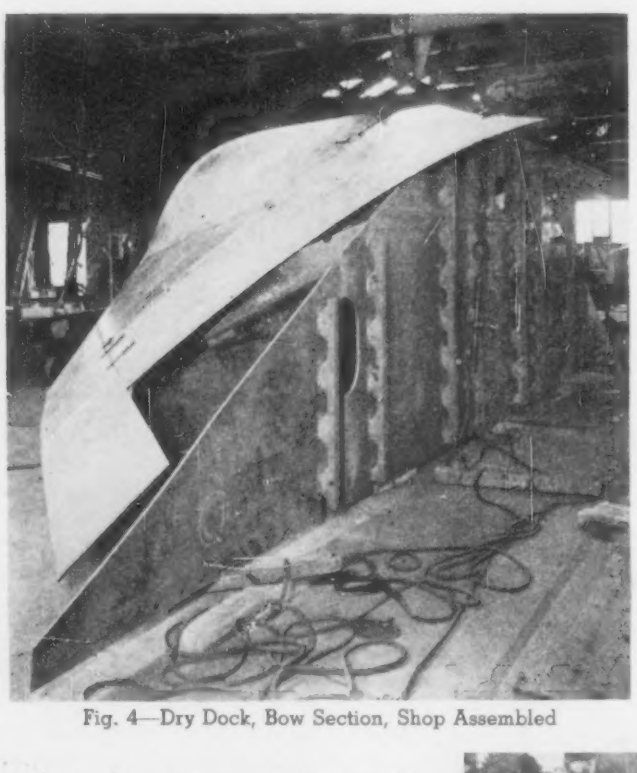

Fig. 4—Dry Dock, Bow Section, Shop Assembled

In all of this shipbuilding work we have found it necessary to clarify not only the terminology used by the naval architects, but we also have to redraw practically all of the drawings made by the naval architects, so that the information we send into our shop will conform to our standard shop practice. Until the present time, the shipbuilding industry was not accustomed to building ships in quantity and, therefore, their drawings were not complete in all details, as it was more economical to work some details out on the actual ship. Our problem is entirely different in that we have to make a quantity of ship sections, which have to be exactly alike, and the men working on these ship sections must have the information to carry on their work correctly and without any relationship to any other adjoining piece or section. Our problem, therefore, is to arrange the work in the shop so that it can be produced in quantity and not as a "make one" item.

In order to make our bill of material for the steel required, we first must analyze all the information submitted to us by the naval architect. We take into account mill tolerances, the shrinkage of the finished welded steel sections and the over-all width or length of the piece, which might be influenced by the curvature of the ship. Many times we are working from incomplete information.

With this incomplete information as a start, we next lay down the ship's lines of our sections on the template floor, so that we may determine any intermediate point not covered by the drawings. These ship's lines also enable us to check the molds which have been furnished to us by the customer and in the event that these molds have been damaged, we are in position to make necessary repairs. We also use these ship's lines and molds to check our bill of material.

At the same time that our shop is laying out the ship's lines, our engineering department is studying the ship's drawings and transferring the data to our own drawings, which are easily read by our workmen, and which fit into our production routine. We attempt, as far as possible, to put definite dimensions on our drawings for the guidance of our men, instead of following the general shipyard practice of using full-sized molds for every piece.

Believe it or not, changes are made from time to time

Fig. 5—General View of the Shop, Showing Fabrication of Hull Sections for Maritime Commission Vessels

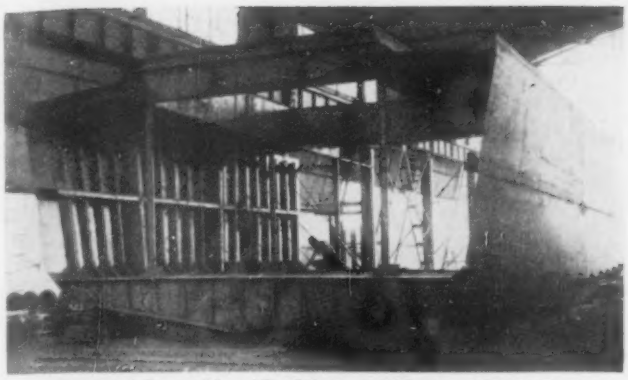

Fig. 6—Trial Assembly of Prefabricated Hull and Deck Sections Forward of Midship Army Cargo Vessel

by the naval architects. These changes are a necessary evil; they cannot be ignored and to avoid confusion, we are obliged to carry these changes through every detail of our drawings and shop routine.

Our shipping pieces must conform to the over-all dimensions called for by the drawings; and the edges which join parts made by others must be in strict accordance with the theoretical ship's lines. To accomplish this, we use fairly elaborate jigs and fixtures, which would not be required in a shipyard. These jigs must be made accurately, and we have found it advisable to assign engineers from our office, who are familiar with this work, to direct the making of these jigs in our shop and also to stay in the shop long enough so that the routine of the manufacture of the ship sections is thoroughly understood by our shop men.

One of the most important points to insure success in the prefabricating of ship sections is to have the material cut to size as accurately as possible, and have all edges properly prepared for welding. In doing this, consideration has to be given to the possible shrinkage due to welding.

In contrast to the practice of some shipyards of cutting pieces to fit in place, we follow the general practice of steel fabricating plants of making up these small pieces in advance, so they will fit into the final assembly. In order to do this we attempt to get complete information of all details on our drawings, so they can be cut to size and actually fit into the final assembly without further burning.

Another important point in the prefabricating of ship sections in a fabricating plant is to arrange the welding in such a manner that the shrinkage and warpage will be reduced to an absolute minimum. As all of the ship jobs which we have fabricated involved a large amount of duplication, we arrived at a satisfactory welding procedure for each job, which practically eliminates any forcing of the steel members to bring them into proper line. In this welding we must keep constantly before us the maintaining of the ship's lines, not only at the meeting points where our sections join sections made by others, but also in between, so that the outside of the ship will have the smooth transition curves desired by the designer.

The principal requirement of all ship fabrication is seaworthiness, which compels the shipyard or fabricator to provide water-tight or oil-tight welded joints. Units which can be tested at the shop are inspected for leaks by filling the sections with compressed air and applying soap and water solution over all seams. Sections which cannot be so tested are given extra scrutiny by our inspectors.

Because of need for training welders quickly, we arrange our work so that most of the welding is positioned for simple down-hand welds and we deliberately avoid any overhead welding. This in is contrast to most shipyards, where overhead welding is general practice. We also use a large positioner for some of our ship work which is not common practice in a ship yard.

In order to keep a continuous supply of welders, we run a school for apprentice welders. All welders used on ship work are qualified in accordance with the requirements of the specifications for the particular job being fabricated. We have found it advisable to have a very rigid inspection of our welding, in order that there will be no rejection of finished pieces, and also to keep our welders on their toes producing good welds. To this end, we have employed welding specialists from Robert W. Hunt and Company to work at our plants to check the welding produced by our welders, and to supplement the inspection of our own inspection department.

As our work is performed far away from the shipyards, and must be shipped by cars, we are faced with the problem from the beginning of producing finished pieces that can be loaded to fit within the clearance lines of the railroads. Before loading, we make a final inspection of the finished section, for correctness of contour and size and the quality of workmanship.

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(*Continued on page 127*)

Production Spot Weld Testing*

By Capt. James K. Dawson, A.U.S.†

IN ORDER to favorably present the process of production spot weld testing, it will first be necessary to explain a few tests and results that brought about the development of this process.

The first test is that of X-raying spot welds. As provided in Army specifications, spot welds on aircraft shall be X-rayed at the discretion of the procurement agency. Usually this will include all structural welding and skin-stressed welds. In one particular case every twentieth assembly of a stressed wing cover was to be X-rayed and the process of welding approved or rejected on the basis of the results. That is, if internal cracks were present in excess of 3%, the remaining 19 assemblies were to be X-rayed and all those having over 3% internal cracks *would be rejected*.

After examining several runs of 20 wing covers, and rejecting them all for excessive internal cracks; a council of welders, inspectors, engineers and manufacturers began a desperate investigation. And to this date it is still the unsettled question. It is "What is the significance on an internal crack?"

After consulting with factory representatives of the leading spot-welding equipment companies and with the Government Procurement Inspector in charge of welding, special welding procedure with personal supervision by welding technicians was employed. These procedures are factory secrets and can well remain as such because of their outcome. Nevertheless, crack-free spot welds were obtained. The names of the men who aided in accomplishing these crack-free welds are withheld. It was my duty to have the welds X-rayed and examine the film. When after several weeks a method of obtaining crack-free welds was perfected, a set of 20 wing covers were welded. As usual, one was X-rayed and was found to be be completely free from cracks. These 20 wing covers were sent to the assembly line approved. But before they arrived three of them (including the X-rayed one) came apart where they had never been completely welded. The remaining 7 covers were sent to the laboratory and X-rayed. They also were crack free. But after a destruction test and examination of the welds, they also were found to be only partly welded.

The X-ray plates were studied once more and no evidence of irregular or unfused welds could be detected.

A test was then made which, after heavy consideration, proved a point that finally released the covers as stressed spot-welded assemblies with abundant internal cracks. This test should be of interest to all concerned. It consisted of one X-ray plate reproduced in Fig. 1. The spot-weld test strips were welded by different operators on various types of welding equipment, and consequently with a varied heat and time setting.

Each sample Fig. 1 was 0.032-24ST-ALC welded to 0.052-24ST-ALC. These 16 samples taken at random, hit or miss, were stamped and X-rayed. The X-ray film was printed and examined. Various technical experts examined this plate and attempted to determine the good welds by the X-ray film and from the print. None were successful!!! The welds were broken and examined for complete fusion. The aligned photographs in Fig. 1 show these broken welds; No. 7 was used in a fatigue test and is consequently missing.

Close observation of the photo and the X-ray print will disclose findings as follows: No. 4, No. 9 and No. 16 definitely have incomplete fusion not disclosed by X-ray; No. 10 and No. 12 pulled buttons which eliminates them from the test. The remaining welds were completely fused, and contained internal cracks with the exception of No. 3, No. 8 and No. 14 which were crack free.

Test Results

Welds without cracks may have or may *not* have complete fusion. But welds with internal cracks definitely have complete fusion.

After this test was made and conclusions drawn, many stressed members were X-rayed, also test samples were X-rayed. The results of further observations have upheld the above conclusion and never once disproved it.

Although the internal cracks guarantee complete fusion, there are men who still maintain we should not have internal cracks because:

1. Tensile strength will be impaired.
2. Fatigue failure will be increased.
3. Fatigue growth of cracks through Alclad will promote corrosion.

The answer to these beliefs will disprove them. First, if spot-weld test samples are X-rayed before they are pulled in a tensile shear test, it will become quite obvious to the sceptics that spot welds in all types of metal are never weaker, and quite often stronger, if they contain internal cracks. This test is easy to perform and has already been observed by so many inspectors and engineers that it becomes unnecessary to present substantiating evidence.

The second reason concerning fatigue failure is a different matter. Many fatigue tests have been made on spot-welded assemblies, but relatively few have considered the effect of cracks, especially internal cracks.

It is necessary to examine the welds by X-ray before and after a fatigue test if any study of internal cracks is to be made. After selecting spot welds that contained internal cracks, these same welds were submitted to frequency vibration. The test samples being trimmed and shortened until a maximum vibration occurred in the test strip which included the weld. This subjected the weld to as severe stress reversal as could possibly occur due to vibration. This loading was applied to the test samples containing internal cracks until a definite failure occurred. The remains of the ruptured samples were then X-rayed with special care to determine the exact location of the failure, some of which were not visible to the human eye even under a magnifying glass. In every case the failure occurred through the outer edge of the weld and spread away from the weld into the parent

* Presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Auto. Sec., T.I.S., Ft. Benning, Ga., formerly with Bell Aircraft, Buffalo Division.

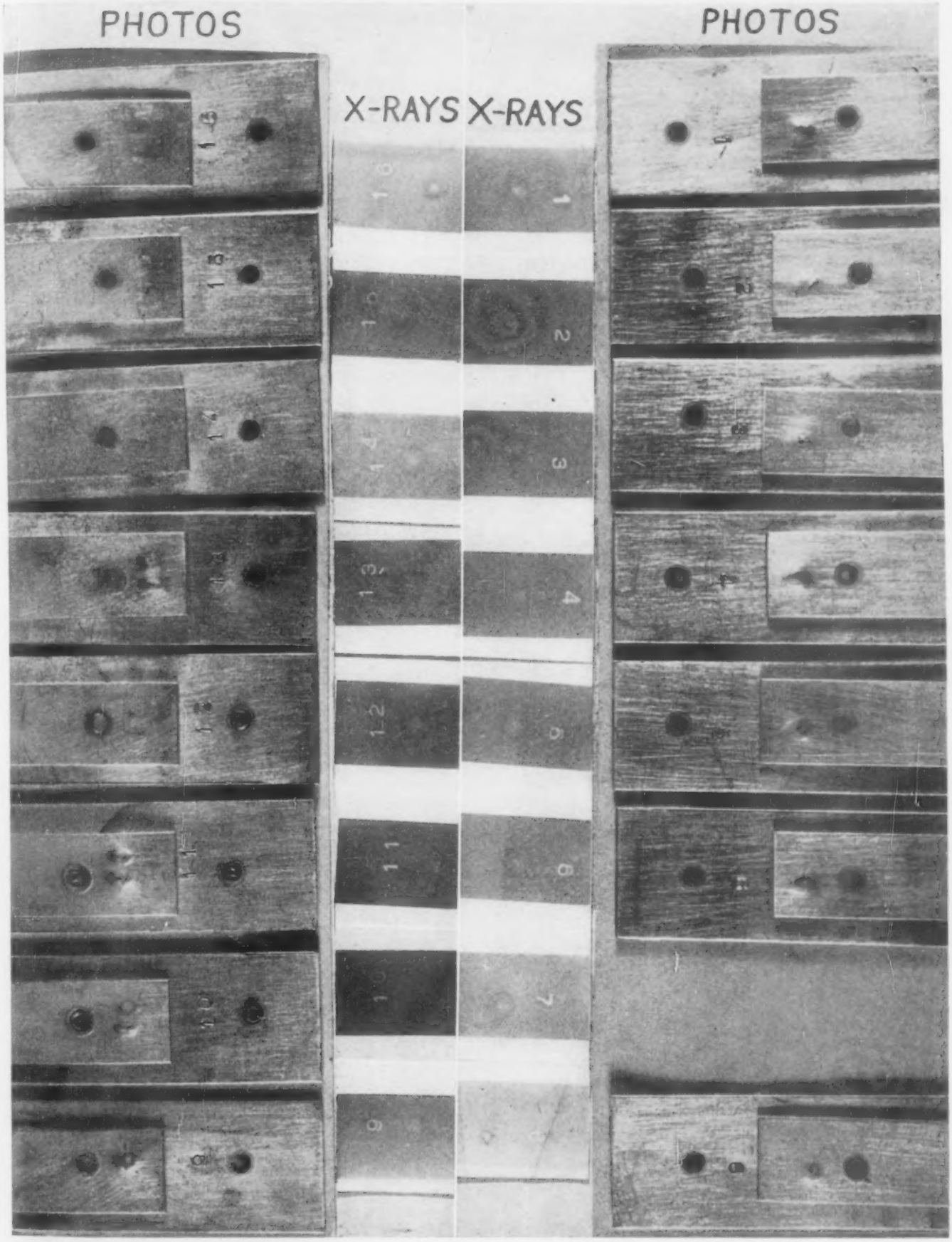


Fig. 1—Printed X-ray Films in Center and Actual Photographs of Welds After Destruction

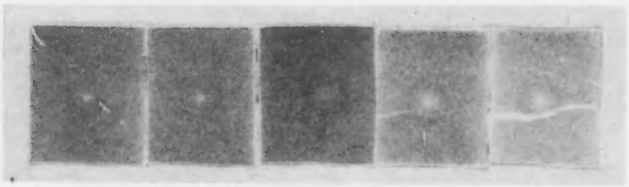


Fig. 2—Printed X-rays of Five Different Fatigue Failures—Four containing Internal Cracks; No. 1, Failure Not Visible; No. 5, Complete Failure

metal. Contrary to general belief the internal cracks did not cause, or even connect up with, the failure cracks. Also the internal cracks gave no indication of enlarging.

Observation of the center surface of the welds showed no evidence of cracks whatsoever. Figure 2 shows several failures of different magnitudes, all being results of this test.

Not being completely convinced that fatigue failure could not occur through internal cracks, a photoelastic test was suggested to provide a study of load concentration in a spot weld. The results of the test are shown in Fig. 3, one cross section and one transparent view (with test strip on one side invisible). These photoelastic tests show the lack of stress in the center of the weld in spite of the artificial cracks present.

The only possible reasoning or logic to explain these phenomena is that the curved contour of the spot weld itself acts as a shield, carrying the load around the edge of the weld and not through its center.

Discrepancies of Spot Weld Testing

Inaccuracy occurs when the assembly being spot welded cannot be duplicated by test specimens. Some of the causes for error are listed in Table 1 with a rough estimate of the deviation percentages from the true strength of the production spot welds on the actual assembly.

Table 1

Cause of Mistake	Average Error
Type of material	100%
Gage of metal	60%
Fit of surfaces	80%
Reversal of position	20%
Age of cleaned surface	1 to 100%
Direction of grain	8% maximum
Lack of cleaning	50 to 100%
Method of cleaning	90%
Alignment of tests	20%
Accuracy of tester	13%
Age of spot weld	6%

Type of material should be a trade knowledge of all spot welding operators and inspectors. This can only be acquired by daily contact with the different materials. Frequent testing of spot-welding setups by operators and inspectors soon gives them a working knowledge of how to match material and thickness of jobs to be welded. Matching of material can be accomplished on a Rockwell machine with the use of Rockwell chart (Table 2).

The first 15 min. (approximate) of aging of cleaned surfaces on aluminum and magnesium are the most critical. Avoid all tests just cleaned.

It really is not necessary to make a *pull* test on every setup or on every check period when spot welding. It has been proved and put to use, the idea of welding control by spot diameter.

Table 2—Rockwell Hardness

St. St. H	A 68	C 35	G 101				
St. St. ½ H							
St. St. Annealed	A 50		G 52.5	B 82	K 92	F 105	
24 St. Al Al.	A 46		G 39	B 75	K 86	F 100	
24 St. Alc.	A 44		G 32	B 70	K 81	F 97	
1025 Steel	A 42		G 25	B 65	K 77	F 94	
52 SH	A 38			B 56	K 69	F 89	
1020 Steel	A 34			B 47	K 61	F 84	
52 S ½ H	A 30			B 38	K 54	F 78	H 101
3 SH Magnesium	A 19			B 13	K 32	F 64	H 92
3 SO Magnesium					K 20	F 56	H 86
24 SO Al Al.						F 49	H 85
24 SO Alc.							
52 SO						F 45	H 80
2 SH							
2 S ½H						F 34	H 76
2 SO Aluminum							H 40

Definite geometrical relationship between spot diameter and tensile shear strength of spot welds *does not exist*. However, from the practical tests made over a period of time in the shop, certain minimum spot diameters have been established which never fall below the Army or Navy specification strength. This does not mean that a larger spot does not sometimes barely pull the required amount, but rather that a spot larger or that large has never been known to fall below the minimum requirements as set forth by specification standards for that particular gage of that particular alloy. (See Table 3.) The log-log curves in Fig. 4 are the developments of the empirical formula of the correlation.

Smaller spots might meet the specification requirements but usually they will be burned, indented or externally cracked which rules them out. If a welding operator knows his material and gage and the corresponding spot diameter, he can set his machines without a pull test and have no fear of the results of company or Government inspectors taking a sample of his welding for laboratory tests at any time.

The strength of the weld is not everything. Burned and cracked welds can easily be detected and should immediately be corrected. Inconsistency of welding can only be determined by making a series of tests, the more tests, the greater the proof. Five spots in a row are usually enough to detect any great fluctuation. Ten test strips, 1 x 4 in., for every setup, would make a pile of scrap metal in no time. When production starts rolling, it is practically impossible to put five spots on two strips of sample material and break each of them in a tensile machine; but by twisting them apart with circular shears, each spot when it is made, directly by the tips

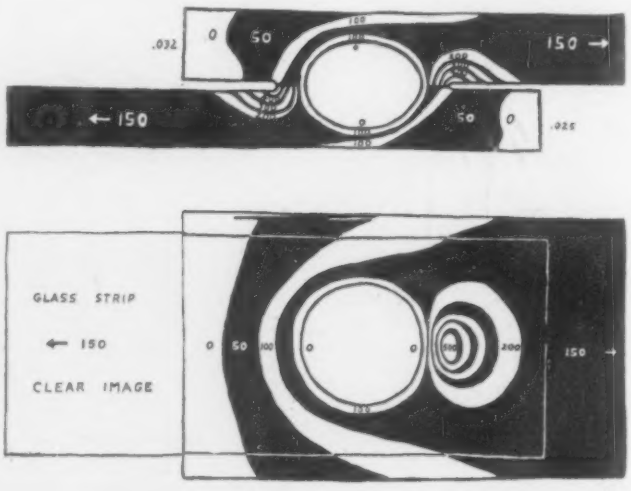


Fig. 3—Photoelastic Study of a Stressed Spot Weld

Table 3—Minimum Diameter and Shear Strength for Single Spot Weld

Make five tests. Use thinnest sheet and smallest diameter. The number before the diagonal is for the inside fused area and is in 1/64 of an inch. The number after the diagonal is the tensile strength in pounds.

Thickness of Thinnest Sheet	24 ST. & Alclad 11067	Annealed Stainless 11068	Full Hard & ½ Hard Stainless	X 4130 1020-1025	52 SO Al Alloy QQ-A-318	Magnesium Alloy 11317	2 S Al Alloy QQ-4-561
.010	5/65	5/190	5/275	5/100	6/60	6/50	6/40
.016	6/110	6/350	6/500	6/150	7/105	7/60	7/52
.020	7/140	7/445	7/650	7/250	8/137	8/75	8/68
.025	8/185	8/616	8/878	8/340	9/178	9/106	9/80
.032	9/257	9/916	9/1296	9/525	10/235	10/151	10/118
.040	10/345	10/1350	10/1900	10/750	11/310	11/202	11/172
.045	10/405	10/1670	10/2350	10/925	12/365	12/234	12/183
.051	11/479	11/2065	11/2914	11/1125	13/440	13/273	13/220
.064	12/687	12/2906	12/4152	12/1600	14/618	14/357	14/306
.072	13/844	13/3395	13/4868	13/1825	15/735	15/411	15/365
.081	14/1049	14/3917	14/5530	14/2175	16/867	16/472	16/427
.093	15/1110	15/4553	15/6123	15/2525	17/898	17/557	17/480
.125	18/1190	18/5450	18/6600	18/3000	20/920	20/800	20/520

and immediately welding another spot, five spots can be tested with two strips of metal 1 x 5 in. and have a tensile shear specimen left to pull if necessary.

A destructive or preloading test should be made by putty knife insertion between the two sheets of metal pushing them apart by tapping the knife with a nonmetallic hammer. If the knife is pushed up near the weld, it will open a seam that has incomplete fusion and will not damage a seam that has good welds. The right-sized knife has been found to average twenty-two thousandths in thickness.

When production starts sometimes it does not slow down for testing and inspections. The poor fellows doing the testing and inspecting for the spot-welding machines, are stretched between the machine and the laboratory equipment. In the case where the inspector has a small Detroit tensile testing machine at his disposal, then he is only stretched between two machines instead of two separate departments.

Think how much better it would be to have a method of inspection that would test welding production right at each machine. This can be done without any additional equipment, without any additional inspectors, without a tensile testing machine and without a laboratory. By checking the tensile shear strength of several spot welds right at the machine, production could be resumed immediately or an incorrect setup could be immediately corrected and then production resumed. As a matter of

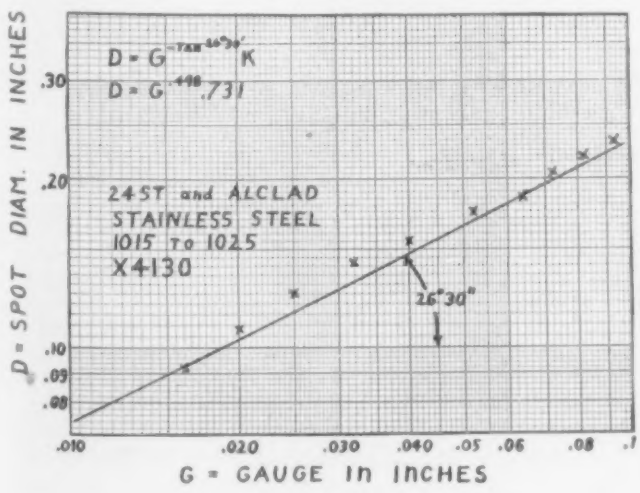


Fig. 4 (*A*)

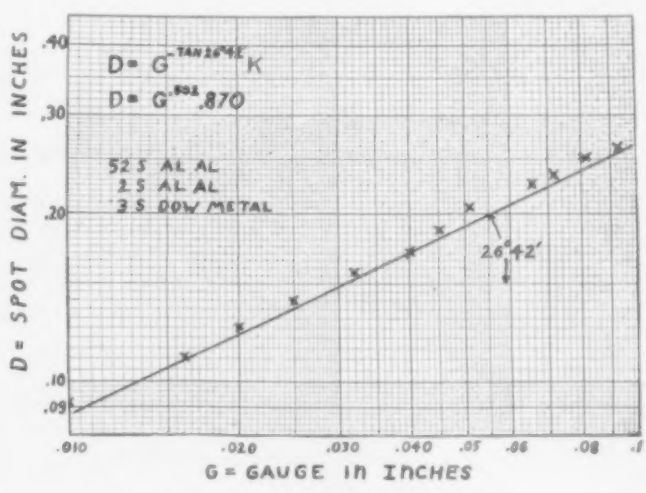


Fig. 4 (*B*)

fact, trustworthy operators can make their own tests and corrections without as much as turning their heads or getting up if they are lucky enough to be seated.

Proposed Production Spot Weld Tests

1. Using two test strips, 1 x 5 in., of corresponding thicknesses and cleaned by the same method at approximately the same time as the assembly being welded, make five welds in succession breaking each weld before making the next one. The weld is to be broken by twisting the test strips in a plane parallel to their flat surface so as to shear the weld through the button or slug.

2. Observe the tip impression for bad burns, splash and cracks. Observe the sheared slug for excess splash, incomplete fusion and spot diameter. Measure the smallest spot with a scale in sixty-fourths of an inch. Check diameter for tensile strength against table of correlations in Table 3.

3. Check every assembly and every spot-welded seam for external cracks. Also check approximately every sixth spot for possible inconsistency and lack of fusion with a twenty-two thousandths dull edged putty knife.

Credit is herewith given to the following named Bell Aircraft employees for their assistance in obtaining the enclosed information: S. L. Rich, K. Youngs, J. Stuart, R. L. Brown, C. Moore, T. Nolan, G. Perry, R. Price and N. Sheppard.

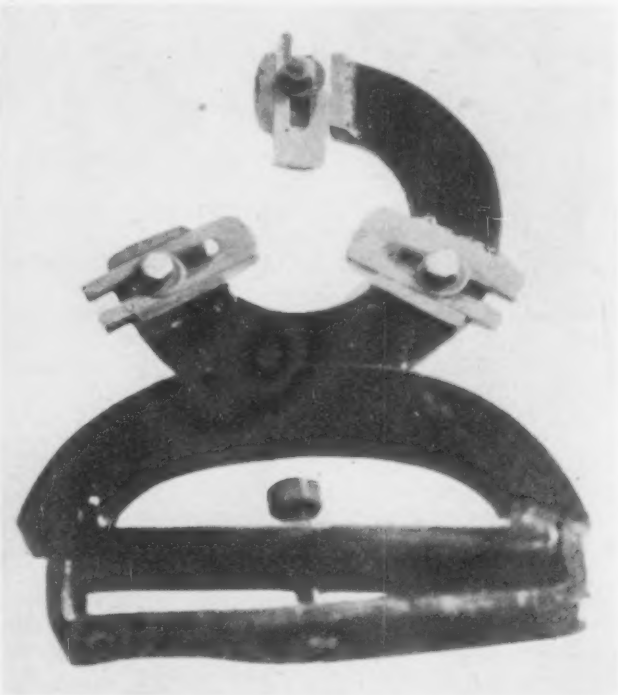
Arc Welding Builds Steady Rest for Lathe from Scrap*

By S. Craig Cairns†

IN THIS day of critical materials and tools, the small welding and repair shops find that it is impossible to procure the needed tools and equipment required for the repairs of hundreds of jobs that are brought in to them.

In writing to the Hobart *Arc Welding News* Contest, the Crivitz Repair Shop, Crivitz, Wis., found it impossible to buy a steady rest for their lathe, so it was either a case of turning down some of the repair work or design a rest of their own. Looking around the shop, a number of pieces of scrap were found that would serve the material purpose and in a very short time the steady rest was finished and attached to the lathe.

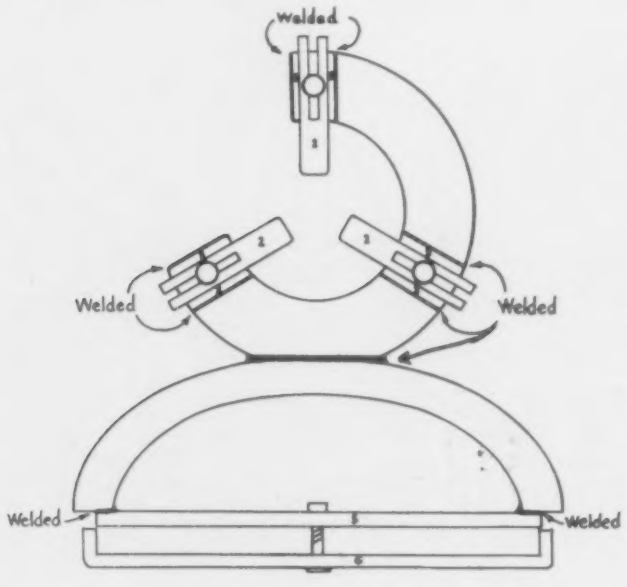
Constructed entirely of discarded scrap, most any shop



can make a similar rest. This tool compares favorably with a factory-built steady rest, and the cash saving alone makes it a worth-while project for all shops. As the iron used was discarded scrap, the material cost was eliminated; labor and preparing material for welding, cost of electrodes and power for welder all together did not amount to over $2.50, and this steady rest will handle practically any work that a factory one costing around $25 will handle.

* This was one of the prize winning entries in Hobart's *Arc Welding News* Contest sponsored by The Hobart Brothers Co., manufacturers of Electric Arc Welding Equipment.

† The Hobart Brothers Co., Troy, Ohio.



Material Needed and Procedure

Cut out ring (1) in perfect circle from $^3/_8$-in. plate with torch, cut opening in circle with hacksaw and grind off bottom of circle for fastening to clamp. Face one side of circle in lathe; locate three bolt holes equally spaced. Make three jaws (2) of $^1/_4$ x 1-in. mild steel and hard surface the tips with Stoody; bolt the jaws to the three bolt holes. Make six guides (3) of $^1/_4$ x $^1/_4$-in. mild steel and lay guides to fit snugly against jaws and weld along edges. The bracket (4) is constructed of three pieces of $^1/_4$ x 1-in. mild steel. Bend and place two outer strips edgewise and weld to center strip which is flat, forming a channel. (5) and (6) are made of $^1/_2$ x 1-in. mild steel.

Gas Weld and Furnace Weld Tubing for Construction Purposes*

By A. C. Weber†

RECENT developments in the manufacture of gas weld tubing have resulted in wide application for pipe and light wall tube in the construction field. In addition to the better known structural uses, such as welded short span trusses, stair and deck railing, portable building frames, etc., many unique applications of tubing have become possible through the economy and increased strength of oxyacetylene welded pipe seams.

Two processes of manufacture involving acetylene welded seams are now generally used to produce tubing. The first of these, the fusion weld or fire weld method, employs a regular pipe furnace for preheating of the skelp before acetylene welding heat is applied to the skelp edges immediately before shaping in the pipe bell. Tubing made by this process is produced with the same rapidity of standard fusion weld or butt weld pipe.

The second and currently more widely used process of tube manufacture is the gas weld method wherein strip is cold formed to circular cross section and then gas welded by concentrated heat applied to the abutting edges of the strip.

* Presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Research Engineer Laclede Steel Company.

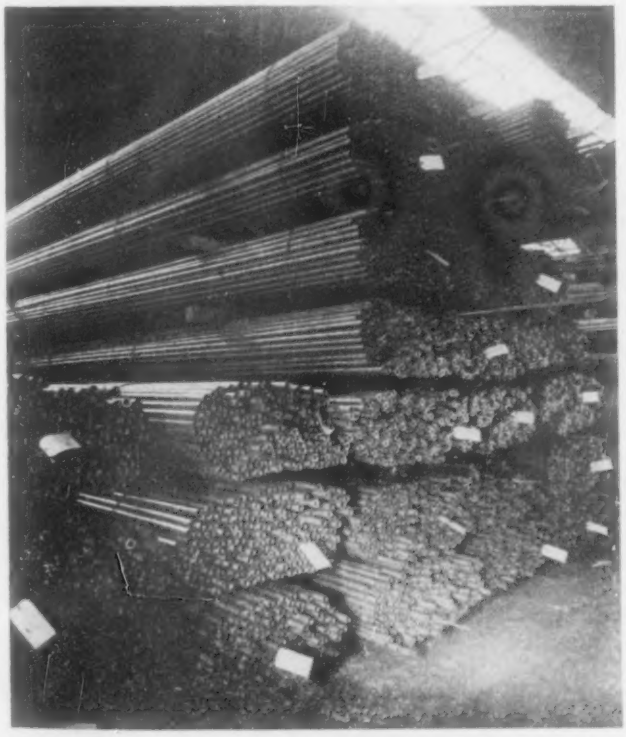


Fig. 1—Stock Pile of Furnace-Welded Steel Tubing in Mill Warehouse Prior to Shipping

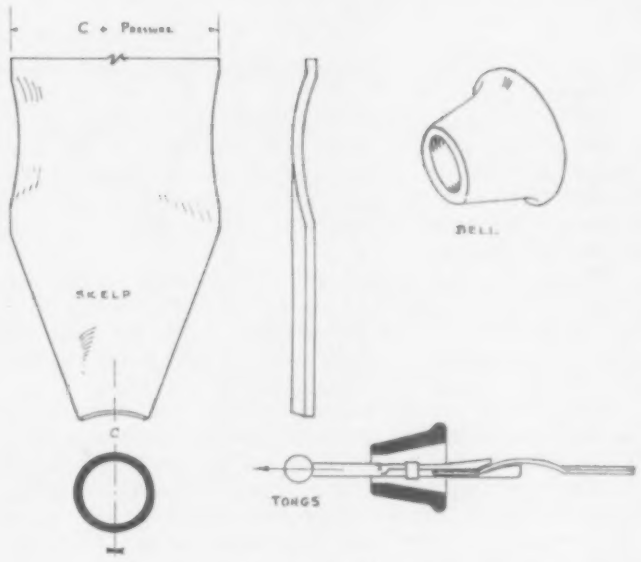


Fig. 2—Diagram of Skelp Ends and Its Forming Into Tubular Section as Well as Details of the Pipe Bell Die and Tongs

Before dealing with any specific construction applications of acetylene welded tubing, it would be well to devote some study to the details of both processes.

Furnace Weld Tubing

We will consider first, the furnace weld or fusion process. Tubing ranging from $^5/_8$ in. O.D. x 0.072 in. wall thickness to $2^1/_2$ in. O.D. x 0.109 in. wall thickness is produced from low-carbon skelp. Rimmed steel with a carbon range of 0.07 to 0.10 and an average 0.35 manganese content is furnished in skelp width equal to the circumference of the finished tubing plus 5 to 8% for sizing roll pressure required in the finishing of the tube.

The skelp, after pointing to permit easy entry into a pipe bell and to fit withdrawal tongs, is charged on the hearth of a regular regenerative type tube furnace. This furnace, permitting delivery of pipe at the withdrawal rate of between 250 and 650 ft. per minute depending upon the size, is gas fired with reversal of firing every quarter hour. A 2600° F. temperature is attained in the skelp section prior to withdrawal from the delivery side of the furnace. Charging of the skelp is effected from a charging car moving laterally across the open rear end of the furnace. The skelp is directed into position on the hearth by entering guides on the forward end of the charger while the skelp is projected into the furnace

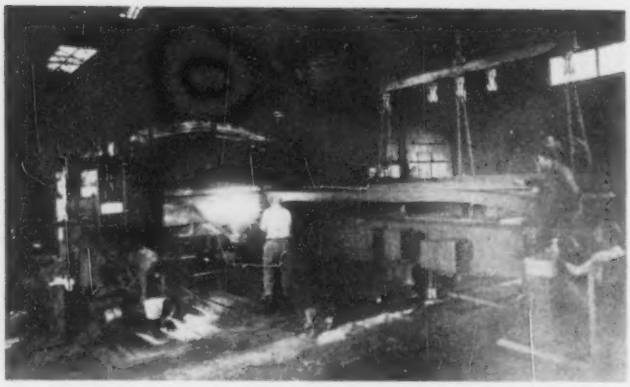


Fig. 3—View of Skelp for Furnace-Weld Tubing Being Fed Into Charging Side of Pipe Furnace for Heating to 2600° F.

by means of rotating magnetic rolls at the forward end of the car.

As an integral part of the withdrawal bench at the delivery side of the furnace, a welding head is mounted immediately ahead of the pipe bell die (see Fig. 4). The heated skelp is withdrawn from the hearth through the welding head by an operator riding the forward end of the withdrawal bench.

The pipe tongs applied by the operator to the preheated skelp are gripped by dogs on the traveling chain of the withdrawal bench, carrying the skelp from the furnace through the oxyacetylene welding head and into the pipe drawing bell for final forming.

The welding head consists of a series of water-cooled castings approximately 15 in. long with a sufficient number of jets directed on the edges of the skelp to produce a $^1/_8$-in. maximum heat penetration for fusion welding. At the welding tips a gas mixture in the proportion of one part of acetylene and four parts oxygen feeds the 6000° F. flame. Since the skelp is already preheated to approximately 2500°, a fusing heat is easily attained as the skelp passes through the welding. The welders working at 15-min. spells at the delivery side of the furnace can maintain a continuous operation at high speed resulting in production footage well in excess of 200 ft. per minute.

Tubing welded by this method is furnished with plain ends and is tested to a specification pressure of 600 to 800 psi. Tubing manufactured from low-carbon steel by the fire weld process lends itself very well for fabrication into construction products and items requiring field assembly.

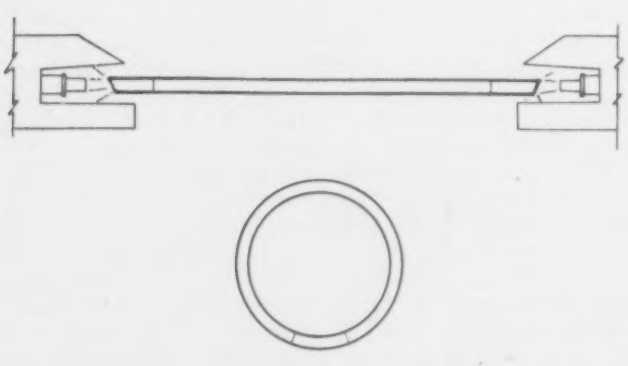


Fig. 4—Diagram Showing Skelp (Above) for Furnace-Weld Tubing Being Drawn Through the Welding Head for Producing Maximum Heat Along the Edges

Gas Weld Tubing

The cold or gas weld process, requiring far less equipment for production, accounts for the majority of thin wall tubing produced. Strip steel may be used in either cut lengths or in coils with a carbon content varying upward from 0.05 to as high as 0.40. The preliminary cold forming of the tube, the welding and the cut-off are usually incorporated in one continuous machine.

As in the furnace weld process, the skelp or flat strip entering the forming rolls is furnished in width equal to the circumference of the finished tube plus 5 to 8% allowance for pressure sizing.

The strip entering the forming rolls is progressively formed into a tubular section as is indicated in Fig. 7. A combination of vertical and horizontal rolls progressively turns the edges of the strip upward and inward, forming it to a circular section. As this circular section approaches the welding rolls, a water-cooled fin carried on a centering roll slips between the upturned skelp edges, holding them in exact alignment.

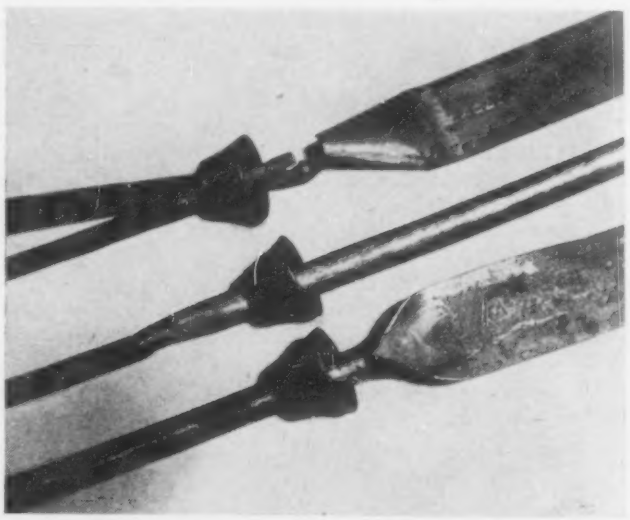


Fig. 5—Photographic Developments of Forming Furnace-Weld Tubing; Insertion of Tongs Through Bell for Gripping Hot Skelp

The tube is welded by acetylene flames from a welding head set between a set of horizontal guide rolls. Following application of the gas welding heat and the completion of the weld, the tube is carried through a set of pressure rolls. The pressure of these rolls is governed so as to impart a forging action to the inside of the developed seam.

Two sets of jets are employed within the welding head, the first serving as a preheating section in which a mixture of one part acetylene and three parts of oxygen is burned over the weld area. This preheating is followed immediately by the application of the welding flames which employ a mixture of one part of acetylene to two parts of oxygen. These second fluxing flames, flow the preheated metal evenly in the seam without cutting or burning through. An acetylene pressure of 8 lb. is used throughout while pressure on the oxygen is varied from 16 to 24 lb. The two-stage welding head contains approximately 125 flames in operation at all times during the continuous seam welding of the tubing.

The speed of production of the gas weld machine varies from 40 to 100 ft. per minute on the more popular tubing sizes ranging from $1^1/_2$ in. O.D. to $^3/_8$ in. O.D. This means that approximately 1 to $1^1/_2$ tons per hour may be produced on one machine. The range of light wall sizes possible on these cold form and gas weld machines

is from $^3/_8$ in. O.D. x 0.035 to $3^1/_2$ in x 0.1875 in. wall thickness.

As the tubing is delivered from the sizing roll, an automatic cutoff is placed so that the tubing may be sawed to length as it is delivered continuously. The automatic cutoff engages the outcoming tube and carries with it for a distance of about 8 ft., during which time the cut is made.

Applications

In the construction field, acetylene welded tubing is being employed more and more in the manufacture of electrical conduit, pressure lines for paint systems, lubricating systems, etc. Light-wall tubing for the protection of electric wiring has been employed extensively for economical field installation because of the ease of fabrication on the job.

Also because of its light weight and easy fabrication, considerable tubing of the various grades of steel has been employed in the fabrication of scaffolding and portable construction fixtures. It is relatively simple to connect the tubing sections either with inserted plugs or collars, and as a consequence tubular scaffolds have proved extremely flexible in their application to all types of building work, such as cleaning, painting and maintenance.

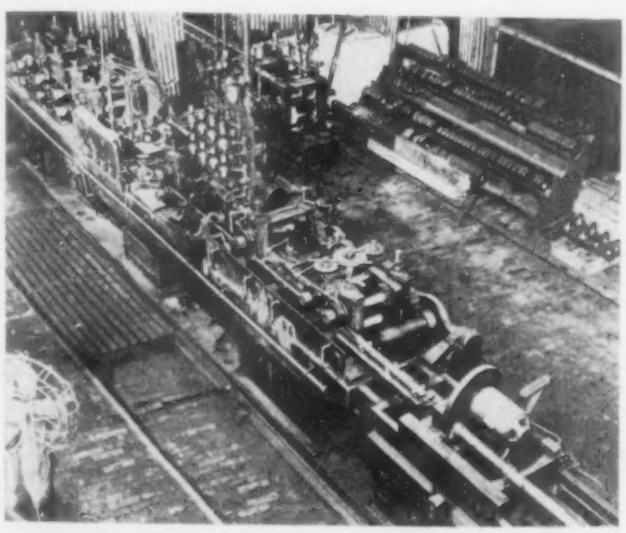


Fig. 6—General View of Cold Gas-Weld Tube Welding Machine

Tubing has been used extensively in concrete construction as embedded reinforcement in expansion joint assemblies requiring the placement of dowels. During the past few years, suprisingly large tonnages of dowel sleeves have been prepared from thin wall tubing for use in airport runway, highway and building construction. The welded dowel assembly indicated in Fig. 11 is typical of such an application, where a complete clearance for embedded load transfer dowels within the concrete pavement has been provided by the strong and yet light weight tube section.

Dam Cooling

One of the largest and most unique applications of oxyacetylene butt-welded tubing in construction has been in the cooling systems of many of the gigantic concrete dams built by the Bureau of Reclamation, Dept. of the Interior. Since 1931 when Bureau engineers initiated the use of tubing in western and Pacific Coast regions, artificial cooling has become general practice for all large drainage structures erected in the west and in the recent dams constructed under the direction of the Tennessee Valley Authority.

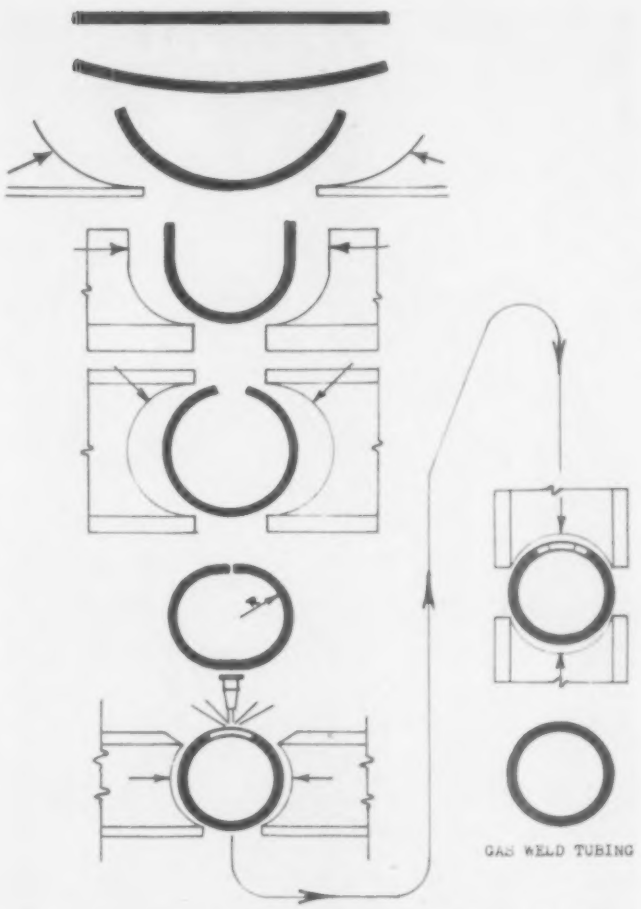


Fig. 7—Diagrammatic Study of Progressive Operation Stages for Forming Gas-Weld Tubing from Cold Strip

Since present-day construction requires rapid placement of temendous masses of concrete in the building of large dams, some method of assured accelerated removal of internal heat from the concrete mass must be employed. Temperature change in the hardening concrete,

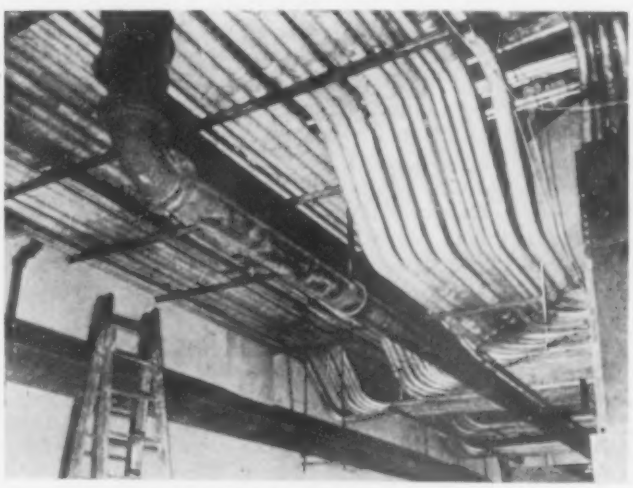


Fig. 8—An Example of Welded Tubing as Used for the Protection of Electrical Conduit

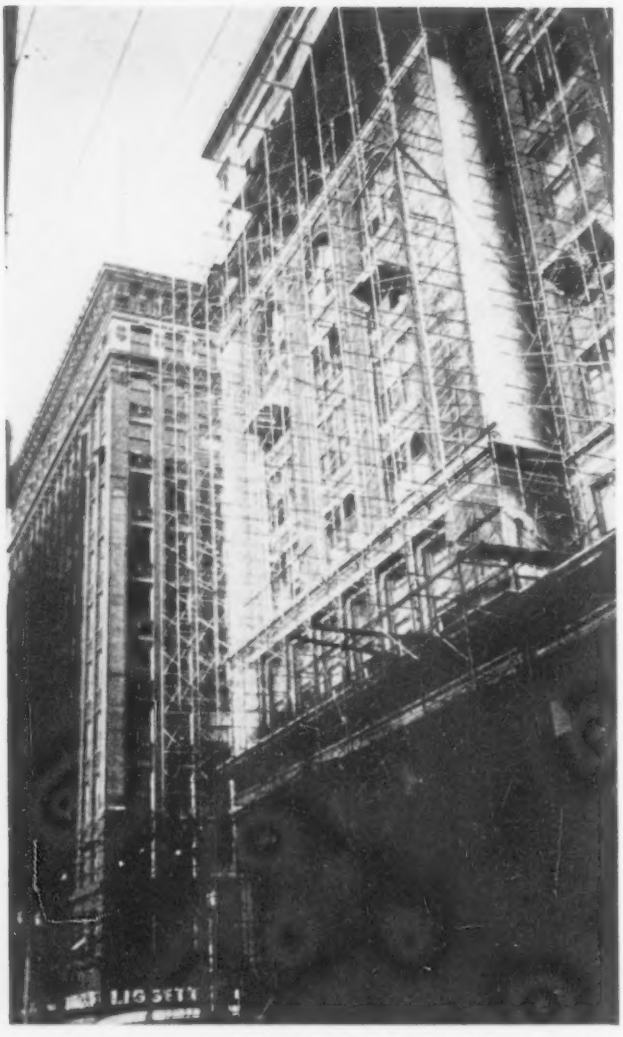


Fig. 9—The Flexibility of Welded Tube Lends Itself to Use for Steel Scaffolding for Building Construction and Cleaning Purposes

whether due to internal or external conditions, if not controlled will set up volume changes liable to create detrimental cracking.

Large concrete masses develop considerable heat due to the hydration of the cement, and in many cases a temperature rise of as much as 140° F. is experienced. Heat loss to the surrounding atmosphere of great masses of concrete under normal conditions might well require 100 yr. or more. In Boulder Dam alone, enough heat was developed during setting of the concrete, which, if translated into units of electrical energy would have satisfied the lighting and power requirements of a town of 10,000 population for more than 2 mo. The loss or emission of heat in a "lift" or "block" of concrete as poured in modern dam building (sometimes 50 x 50 x 5 ft.) is directly proportional to the square of the thickness of the mass. Obviously, volume changes and cracking would result from the slow escape of the immense amount of trapped heat if artificial means were not employed at the time of concrete placing.

Nearly 85% of the total heat of hydration is generated during the first three days that the concrete is hardening. The final temperature of the dam, on the surfaces exposed to normal air and water temperatures, is much lower, sometimes as much as 100° F. less than the maximum concrete temperature during construction. Such large temperature variations from a warm interior to the colder exposed surface are the major causes of cracks. These cracks, dangerous to the structure's stability and detrimental to safety and appearance, may result in redistribution of stresses. It is important that large concrete dams be and remain monolithic units with no leakage allowed.

Numerous methods for controlling the temperature of the concrete have been attempted from time to time. "Low heat" special cements, precooled aggregates, refrigerated mixing water and even the addition of crushed ice to the mix have all been tried in an effort to lower temperature in the placed concrete. Specially designed slots between "lifts" (grout-filled later) have also been introduced into dam construction practice along with a limited rate of placement in an effort to gain temperature control. No better method, however, for the regulation of temperature of the concrete mass has been found to date than that of artificial cooling as herein discussed.

Embedded Tubing Systems

Artificial cooling by circulating cold water through an encased tubing system in the concrete has been found most economical, flexible and effective. Since the dam must remain monolithic, artificial cooling permits the concrete to contract wholly during the construction period. Thus when planned contraction openings occur, they may be promptly filled with cement grout.

The concrete may be cooled uniformly, to a final stable temperature, in a month or two. Artificial cooling

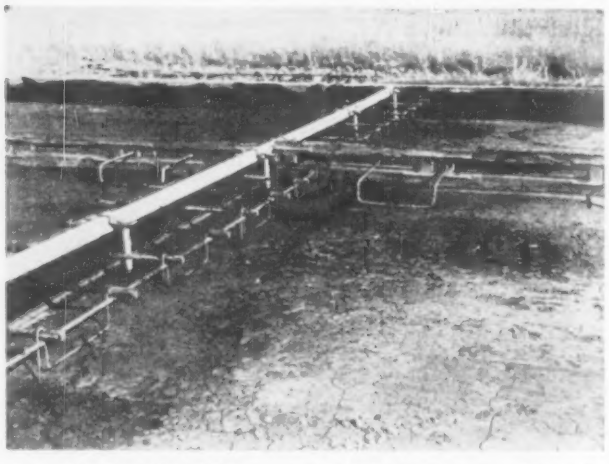


Fig. 10—Welded Tubing Is Used Extensively in Concrete Expansion Joint Assemblies

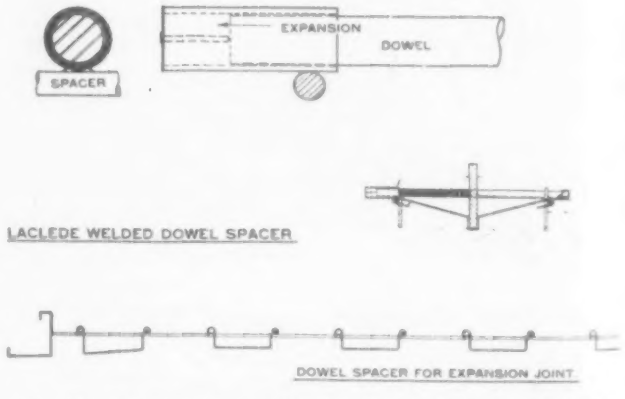


Fig. 11—Diagram Showing the Function Performed by Welded Tube Dowel Spacers for Highway Expansion Joints

also provides for lowering of the maximum concrete temperature and advances the date of temperature strains due to placement with their resulting stresses. Imposing such strains on the "green" concrete in its early age, while it is relatively plastic, provides greater relief of stress through plastic flow or creep than would occur later when the concrete was older.

All parts of the dam may be cooled uniformly or to any degree at any given location. In addition, subcooling is possible where desirable. The embedded tube cooling system is extremely flexible and may be extended from cooling distribution shafts or galleries from within the dam or from either the upstream, downstream or construction faces of the progressively heightening mass.

Oxyacetylene and butt-welded tubing have readily met the requirements for these cooling systems. The average pressure of water circulating an average of 4 gal. per minute in the tubes is about 50 psi., although, under exceptional actual conditions, such may run up to 75 to 100 psi. Accordingly the tubes tested at 600 psi are adequate for all conditions. The tubing itself is of thin wall construction, 1 in. O.D. The Bureau of Reclamation and Tennessee Valley Authority, since 1931, have standardized on this described method of cooling.

Boulder Dam in Nevada on the Colorado River, Grand Coulee in Washington State on the Columbia River, Friant Dam, near Fresno, on the San Joaquin and Shasta Dam, also in California on the Sacramento River, are the largest dams built with circulated water cooling in addition to many others, smaller than those mentioned but mammoth in scale when compared to the largest eastern and mid-western hydroelectric power dams.

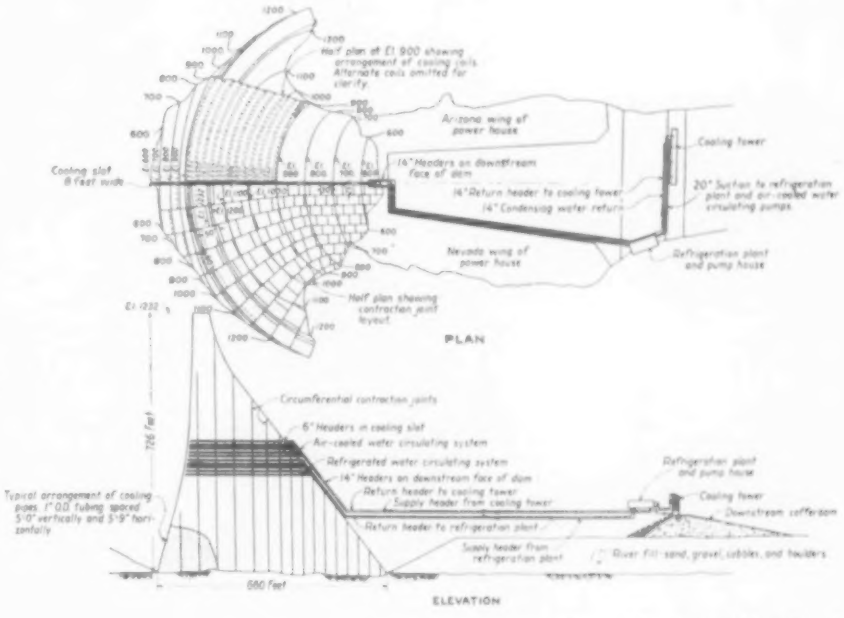
The four mentioned, Boulder, Grand Coulee, Friant and Shasta, in total required over 25 million lineal feet of butt-welded tubing, or nearly 5000 miles. As these four monoliths required the pouring of over 21 million cubic yards of heavy aggregate concrete, it will be seen that such structures require, on the average, slightly more than 1 lineal foot of butt-welded tube per cubic yard of concrete. The recently introduced practice of the Tennessee Valley Authority of forming the semi-circular temporary returns at the sides of each lift from

LARGER WATER COOLED CONCRETE DAMS

Dept.of Interior, Bur.of Reclamation, Washington, D.C., Denver, Colo.

NAME	LOCATION	YEARS	CU.YDS.CONC.	LIN.FT.TUBE	HEIGHT	CREST
Boulder (Hoover)	Colorado R.	1931-1936	3,300,000	3,407,000 (1040 m.)	727'	1282'
Friant	San Joaquin R.	1939-1942	2,045,000	3,460,000 (1055 m.)	320'	3443'
Grand Coulee	Columbia R.	1934-1942	9,926,000	9,784,000 (2982 m.)	550'	4173'
Shasta	Sacramento R.	1935-	6,100,000	8,600,000 (2620 m.)	602'	2860'

Fig. 12—List of Dept. of Interior, Bureau of Reclamation Dam Projects Using Gas-Welded Tubing for Cooling


PLAN
ELEVATION
Half plan at El. 900 showing arrangement of cooling coils. Alternate coils omitted for clarity.
Arizona wing of power house
Cooling tower
16" Headers on downstream face of dam
16" Return header to cooling tower
16" Condensing water return
20" Suction to refrigeration plant and air-cooled water circulating pumps
Cooling slot 8 feet wide
Nevada wing of power house
Refrigeration plant and pump house
Half plan showing contraction joint layout
Circumferential contraction joints
6" Headers in cooling slot
Air-cooled water circulating system
Refrigerated water circulating system
16" Headers on downstream face of dam
Return header to cooling tower
Supply header from cooling tower
Return header to refrigeration plant
Supply header from refrigeration plant
Downstream cofferdam
River fill: sand, gravel, cobbles, and boulders
726 feet
680 feet
Typical arrangement of cooling pipes. 1" O.D. tubing spaced 5'-0" vertically and 5'-9" horizontally

Courtesy Engineering News Record

Fig. 13—Diagram of Gas-Welded Tubing Cooling System Employed for Boulder Dam

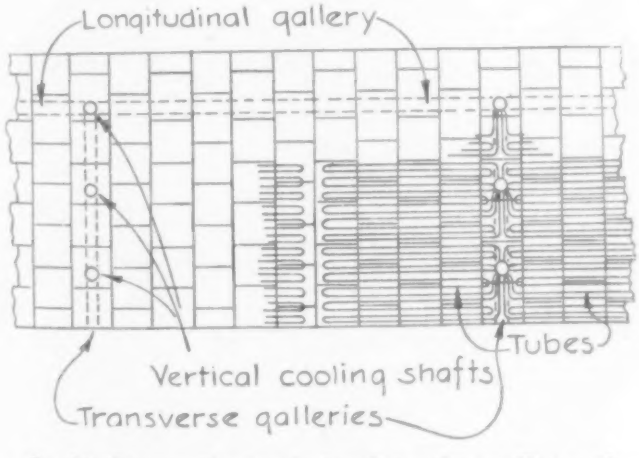


Fig. 14—Diagram Showing Cooling System Layout (Horizontal Plane) and Cooling Shaft and Gallery System

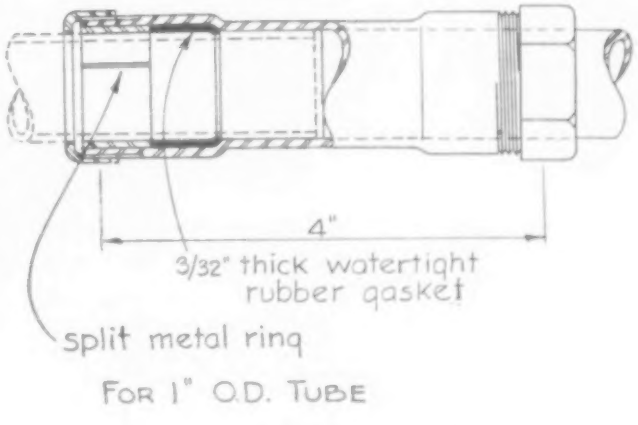


Fig. 15—Diagram of Cooling Tube Coupling

steel tubing instead of using built-up cotton and rubber hose, will add to this proportional requirement.

In many cases the river water taken from the upstream side of the dam is sufficiently low in temperature (less than 50° F., all year round) to be circulated direct through the cooling system. Such is not always the case, however, and at Boulder Dam, the cooling program was carried through in two stages: first, air-cooled water was circulated, followed in the second stage by a circulation of refrigerated water. An atmospheric type of cooling tower was erected for supplying the water for the first stage. The water was cooled by falling over the tower into a collection basin at the foot of the dam, then flowing to a pumping plant. Regional low humidity and natural canyon draft made this method of precooling most effective. The second stage of circulation

Fig. 16—Grand Coulee Dam, Near Completion

Fig. 17—Cooling Tube Return Loops and Anchorage to Rock Floor

with refrigerated water was accomplished through an ammonia compression system rated at 825 tons capacity (one ton of refrigeration is the amount of heat required to melt 1 ton of ice in 24 hr. or a rate of 200 Btu's per minute).

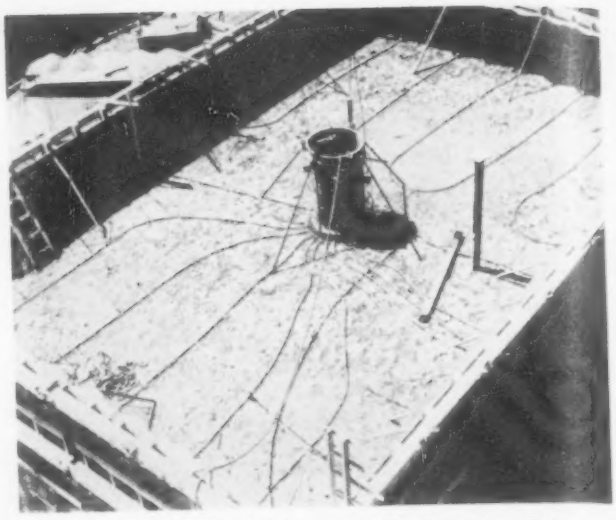


Fig. 18—First Level (Lift) Pouring with Cooling Finan Tubing Out from Vertical Cooling Shaft

Grand Coulee

In the Grand Coulee Dam no mechanical refrigeration was necessary in that the mean annual water temperature in the reservoir is about 45° F. It is less than 50° F. for 8 mo. of the year and less than 60° F. for the four summer months.

The cooling system at this dam (the largest in the world, requiring the pouring of 9,926,000 cu. yd. of concrete), consists of a system of longitudinal and transverse cooling galleries, 7 to 8 ft. high and 5 to 6 ft. wide. These galleries provide space for connecting the cooling pipe headers to the embedded welded tubing. Longitudinal galleries are spaced vertically at 50-ft. intervals throughout the dam while the transverse galleries, normal to the upstream face of the dam at different eleva-

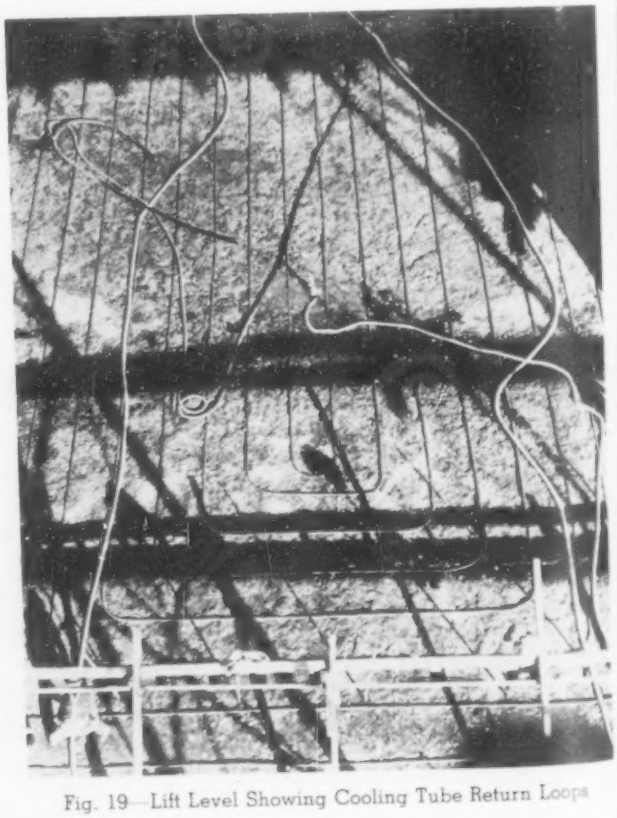


Fig. 19—Lift Level Showing Cooling Tube Return Loops

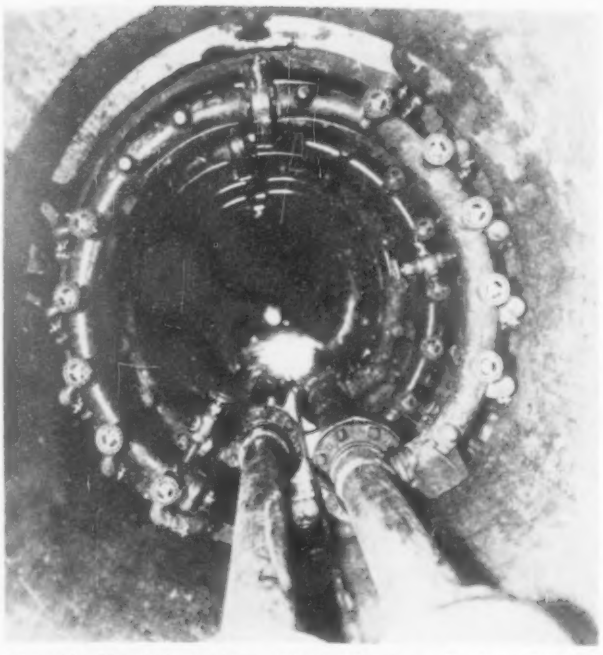
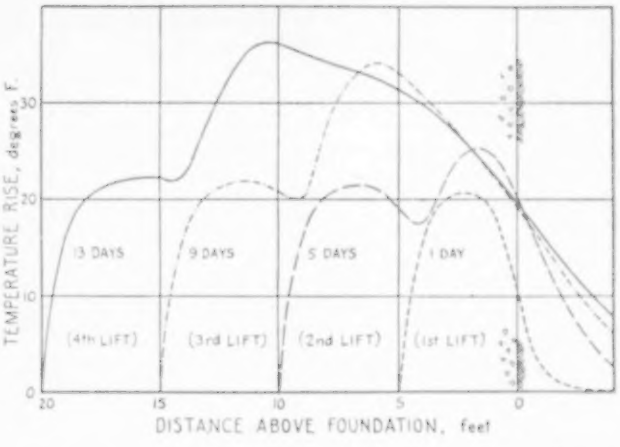


Fig. 20—Vertical Cooling Shaft Showing Cooling Water Manifolds, In and Out

tions, are connected with vertical $3^1/_2$-ft. diameter shafts which provide water inlet and outlet manifolds through which the cooling water is distributed at 5-ft. vertical faces between galleries.

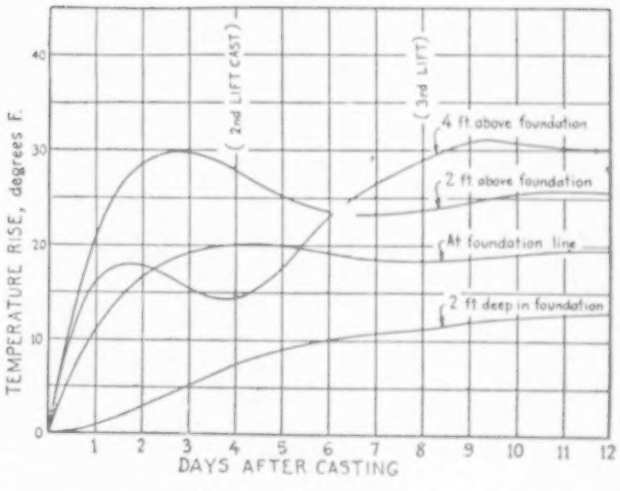
The embedded welded tube coils, about 800 ft. long, coupled with special expansion-type couplings, are laid on top of each 5-ft. lift of concrete after it has hardened, thus providing a vertical spacing of about 5 ft. Frequently, at the base of the dam, as in the case of Friant Dam on top of a rock surface, the initial lifts are only $2^1/_2$ ft. high and a layer of coiled tube is placed atop each lift as well as on the rock foundation, following its contour, prior to the initial concrete pour.

The tubing is fastened securely to the concrete at the inter-lift levels by means of heavy looped wire, previously positioned in the top of the lower lift, with the free ends extending above the concrete inter-lift face level by about 8 in. These ends then span the tube and by



Courtesy Journal of the American Concrete Institute

Fig. 23—Temperature Distributions in Mass Concrete One Day After Casting Each 5-Ft. Lift, on the Basis of Casting one 5-Ft. Lift Each 4 Days



Courtesy Journal of the American Concrete Institute

Fig. 24—Temperature Rises, at Different Points, Plotted Against Time, on Basis of Casting One 5-Ft. Lift Each 4 Days. As No Rapid or Large Temperature Drop Is Observable Within 12 Days, Indications Are That the Ultimate Drop to the Final Temperature May Require Years Unless Artificial Cooling Is Introduced

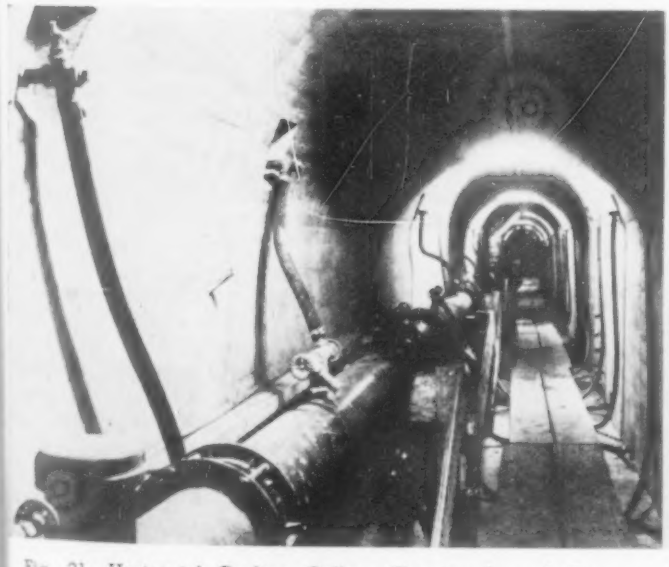


Fig. 21—Horizontal Cooling Gallery Showing In and Out Connections to Welded Tube Cooling Loops

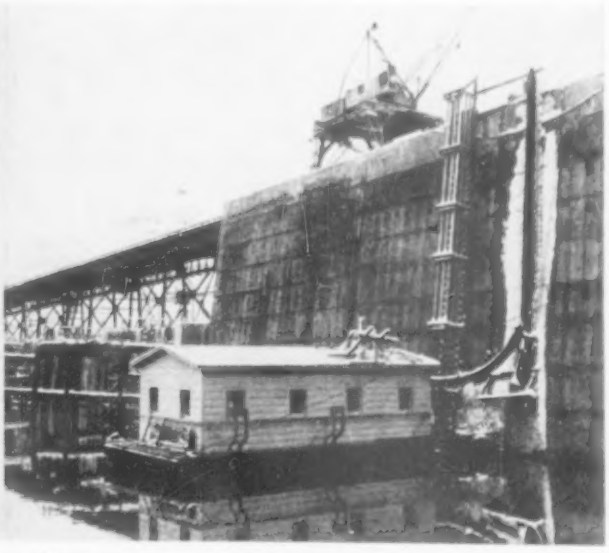
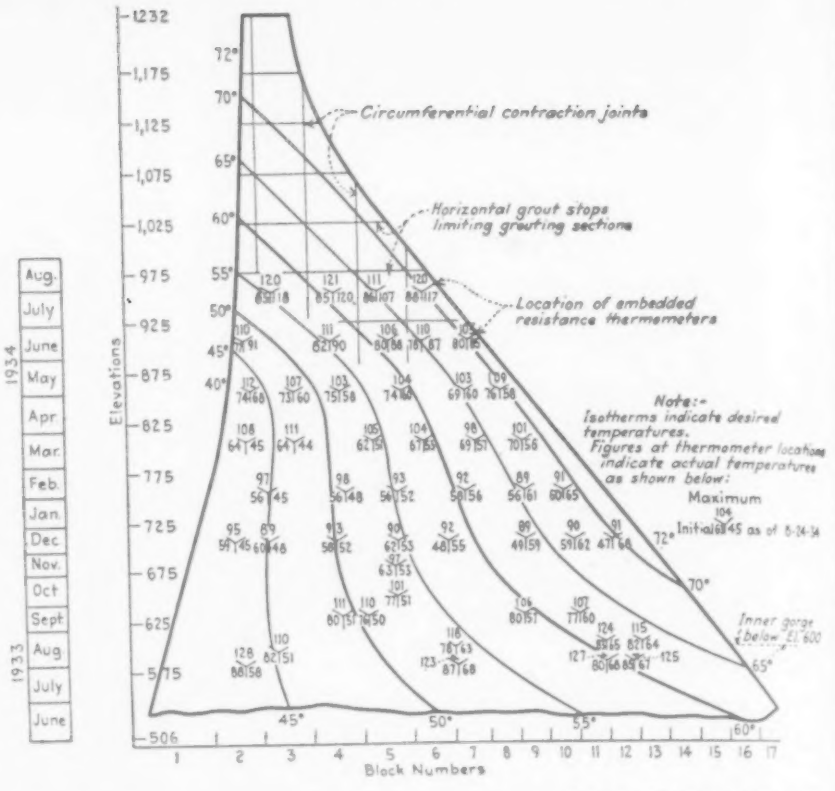


Fig. 22—Pump Barge on Upstream Side for Pumping Cooling Water Into System. In Summer Water May Pass Through a Cooling Tower Prior to Entering System

means of several tight twists hold it securely in place, preventing displacement of the tubes under direct or glancing impact of the falling concrete for the upper lift. Where the tubing is laid on the bedrock beneath the dam it is anchored by heavy wires to pipes or small angle bars positioned vertically in drilled holes in the bedrock. Frequently lengths of additional tube or pipe are placed across a ser es of tube coils and wired securely, tubes to stretcher, at the juncture crossovers, thus presenting a strong network that will maintain its position either under the falling impact or the compressed air tamping of the concrete.

As in the Grand Coulee, the Bureau of Reclamation limits the depth of lift for large dams not to exceed 5 ft. and the rate of concrete placement not to exceed 1 lift in 72 hr. The most favorable time for covering the top of a 5-ft. lift is 4 to 10 days after casting. It cannot be left exposed too long as excessive cooling from the top is conducive to crack formations extending from the surface downward. The horizontal spacing of the tube coils will vary to suit the purpose from 2 to 6 ft. In Grand Coulee it averages 5 ft. 6 in. The coils will extend out from the manifold shaft beyond the initial shaft lift and frequently across several adjacent lifts, then loop and return. Temporary connections from open end to open end of coils are made at the vertical face of the lift as it is cast prior to the coil extension across the adjoining lift.


Circumferential contraction joints
Horizontal grout stops limiting grouting sections
Location of embedded resistance thermometers
Note:- Isotherms indicate desired temperatures. Figures at thermometer locations indicate actual temperatures as shown below: Maximum Initial as of 8-24-34
Inner gorge below El. 600
Elevations
Block Numbers
1934
1933
Aug. July June May Apr. Mar. Feb. Jan. Dec. Nov. Oct Sept Aug. July June

Courtesy Engineering News-Record

Fig. 25—These Isotherms Indicate the Desired Final Temperature, with Data on the Concrete Temperature When Placed, the Maximum Temperature Reached and the Resulting Temperature Due to Artificial Cooling

The desired variation between the upstream and downstream side of a dam is indicated. The water in the reservoir below the penstock intakes (elev. 900) approaches the temperature of water at the maximum density, or 39.3° F., and the concrete near the downstream face, like the rock in the canyon walls, will approach the mean annual air temperature of 92° F.

The temperatures to which the concrete mass must be cooled differ considerably on the upstream and downstream sides inasmuch as there may exist a sizable differential between the reservoir water and the air temperatures. The flexibility of the butt-welded tube water cooling system, supplemented by a refrigeration plant and complete resistance thermometer temperature recording at any given point, makes this requirement a simple matter to fulfill. More than 1200 resistance thermometers were embedded in the Grand Coulee concrete.

Pumping stations may be located on cofferdams, on the river banks or on barges. At Grand Coulee two pump barges were located on the reservoir surface, having a total rated capacity of 3500 and 5500 gal. per minute, respectively, when pumping against a maximum head of 220 ft. The water is pumped through embedded intake pipes between the upstream face and the longitudinal gallery. In the latter, headers from 14 to 8 in. diameter carry the water along the gallery length to the transverse gallery 10 to 4-in. diameter headers, and from these to the vertical shaft radial manifolds and then through the tubular coils at each 5-ft. level. The flow velocity through these coils is not less than 2 ft. per second or 4 gal. per minute for 1-in. tubing. The return flow is collected by return headers, which increase in size as they follow through the return path to the drain outlet for releasing into the stilling basin, as is the case where river water is used. If refrigerated water is used as in the case of Boulder and Shasta and other smaller dams, the water, after passage through the coils, and warmed, is returned to the water coolers and again refrigerated for repeated use.

Under normal conditions from 60 to 90 days are required to cool the concrete to the desired temperature. Following the satisfactory cooling of the concrete, the contraction joints are grouted by pumping through a system of pipes embedded in the concrete adjacent to construction joints. Outlets as well as inlets are provided so that water and thin grout may be drawn off.

The refrigeration system is also filled with grout following complete curing of the structure so that the tubing is made an integral part of the final reinforced concrete mass. Cost of refrigeration on the Bureau of Reclamation work has been between $0.12 and $0.15 per yard of concrete. Of the cost approximately 40% is represented in the cost of tubing and its placement.

The cooperation of J. G. Magrath, Applied Engineering Dept. of Air Reduction Sales Co., and the kind assistance of the Bureau of Reclamation, Dept. of the Interior, is gratefully acknowledged in the preparation of this paper.

The Modern Weldery

By Louis T. Kenney*

AMONG the new or greatly expanded techniques brought on by the war is the art of electric arc welding. All one has to do is to think of Liberty and Victory freighters, of the shift to the welded Sherman Tank, and the adoption of the arc-welding process in fuselage manufacture. Those are just three big spectacular fields in which arc welding has made great and much publicized strides.

The use of arc welding to fabricate housings and other parts for machine tools and Diesel engines are just two more instances out of hundreds that might be mentioned. In this general category, great things are in store for the welding fraternity after the war. Thousands of machines, appliances and things yet unborn will embody welded parts.

When arc welding replaces the riveting process, feasible in thousands of cases, far greater speed is obtained at lower costs. Only the other day an American tanker of all-welded construction resisted a brace of torpedoes that would have undoubtedly sunk her had she been of the more conventional all-riveted construction. Although the deck plates of this ship buckled from the force of the explosion, they nevertheless took much of the "kick" out of the blast and the bulk heads were able to hold. The ship made port. A few more graphic proofs of the strength of a properly welded part like this and arc welding will cut still faster and deeper into the generally accepted domain of the riveter and his hammer.

Years ago when arc welding was largely regarded as a makeshift for some minor mysterious repair, when it was almost exclusively the spark-shooting tool of the repair shop, industry took it lightly. The factory had an outfit, of course, largely for use of the millwright or maintenance crew. Just a handy way to fix something—and there the matter rested.

Today arc welding is a tool of production. Completely equipped welding departments with staffs of expert welding engineers and equally expert fabricators "do their stuff." Thus is production speeded, the product made lighter, stronger, more sightly. And equally important, thus are costs reduced.

Today professional welding companies have also come into being. Welded steel fabricators, they are generally called. They operate by forming and welding parts and subassemblies for an ever widening range of manufacturers. They work from blue prints. They take their place alongside the commercial steel foundry that would prefer to cast the part. They promise to give the foundry a real run for the business. Often they maintain engineering staffs to assist customers to make design changes so that as much of the product as possible can be of welded construction.

The United Welding Co. of Middletown, Ohio, is such an organization. At United many positioners, both of the pedestal type and skid type mount the work. They are all electrically operated and push button controlled. The use of positioners permits the work to be so placed that all welding is down hand, resulting in faster and better work. Other major equipment items include a large Pantograph (burning machine) a 600 ton press brake shears, annealing furnaces of 16 x 8 x 8 ft. capacity and sand-blasting equipment, cranes and rail sidings complete the layout.

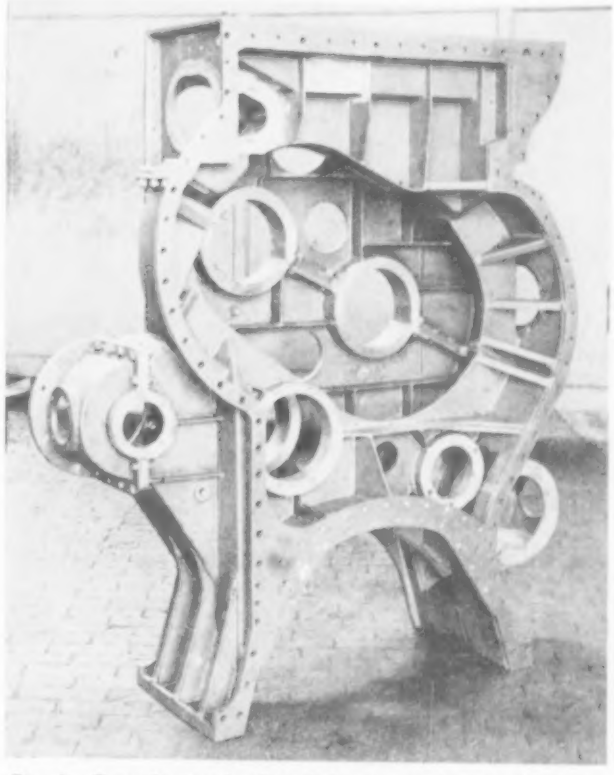


Fig. 1—Gear Casing for Diesel Engine to Go Into PT Boat. Very Complicated Welding Assignment. Many Subassemblies

The gear casing shown in Fig. 1 is also the end housing for a Diesel engine. This assembly posed a real fabrication problem. This is how it was built. It was fabricated of rolled steel plates, bars and shapes. The side plates were gas cut from the flat plate. The bearing pieces were formed from bars gas cut to shape. The various subsections involved were assembled in jigs to make all casings interchangeable. These subsections, or assemblies, were then gathered together to form the complete casing (see Fig. 1). The next step was a trip to the annealing oven for heat treatment to relieve all stresses that might be present. Finally came sand blasting to complete the job.

So handled, we were able to produce a very complicated part for a very exacting customer, the United States Navy, since the Diesel engine of which this unit is a part went either into a submarine or into an escort craft, and had to be right.

It was right—light in weight, relatively speaking, far stronger than a comparable part of cast construction

* United Welding Co., Middletown, Ohio.

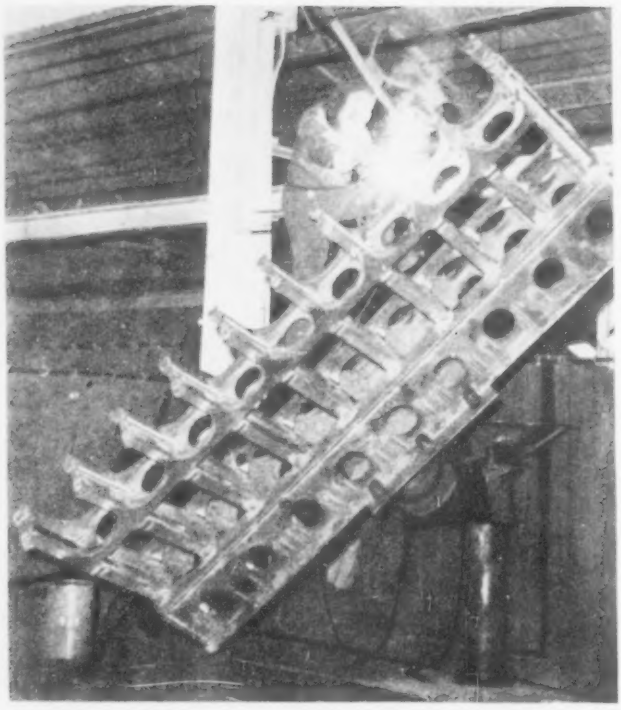


Fig. 2—Diesel Engine Frame. Large and Difficult Work. Thousands of Tons of Such Weldments Built in Past Two Years

could hope to be. It was freed of stresses and strains that might result in failure due to gun concussion or other causes. In addition, the cost was measurably less than would have been the case had patterns been made and the parts cast.

Next to weight saving, the greatest advantage in forming this Diesel gear casing by the welded subassembly process was the certainty of getting a good piece. To cast it would have been most difficult. To get a satisfactory casting of such complicated structure at all, until after several unsuccessful trys, would have been unlikely. That would have been costly in lost time. Obviously, welding was the logical way. This particular part was 60½ in. high, 46 in. wide, 12½ in. deep. Weight only 1875 lb. in the rough.

Figure 2 shows a Diesel engine frame tilted on a positioner so all welding operations can be "down welding" in the interests of better welds and greater speed. More specifically it is the main housing for an 8-cylinder Diesel engine for use on a Navy boat in process of fabrication. This assembly is made up of 102 parts, including forgings, square welded tubing, alloy plates and S.A.E. 10–20 steel. The weight of the finished assembly is 1800 lb. Most of the joints are

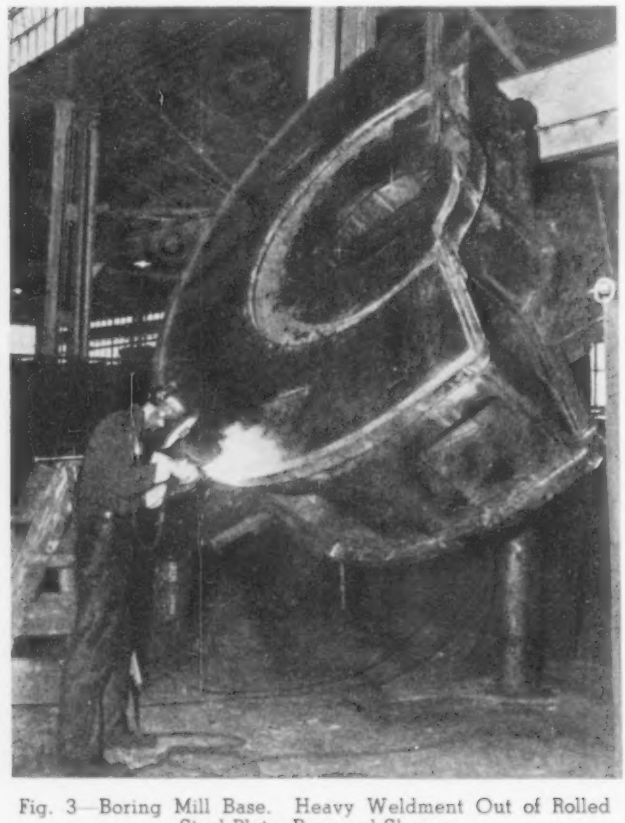


Fig. 3—Boring Mill Base. Heavy Weldment Out of Rolled Steel Plate, Bars and Shapes

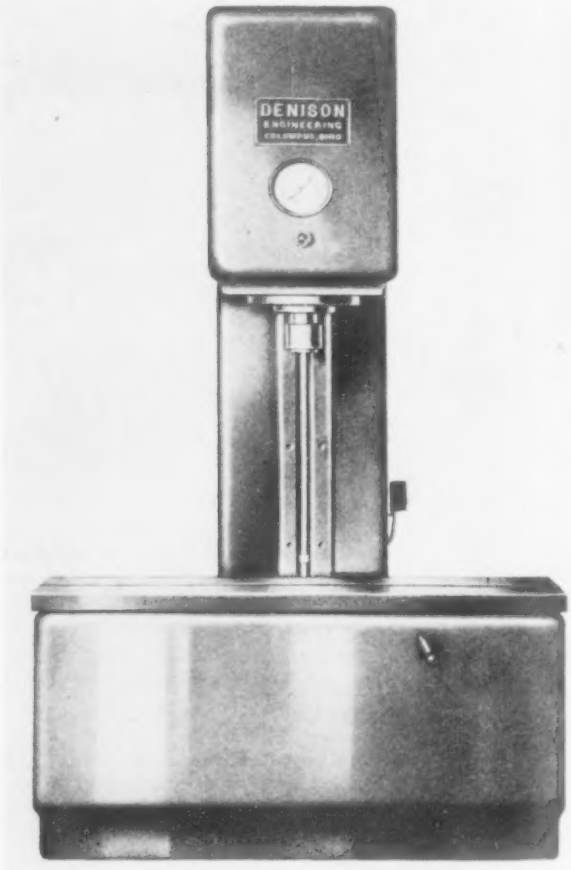


Fig. 4—Large Press Formed Out of Heavy Steel Plate

⅝-in. fillets and there are 450 ft. of welded joints in the assembly. Jigs and fixtures are used extensively in the process of manufacturing this assembly. The maximum allowable variation on this assembly is ±1/16 in.

United have also welded many main housings for a 16-cylinder Diesel engine for use on naval craft. This unit is made up of 248 pieces (same assortment as for the assembly shown in Fig. 1) joined by 800 ft. of ⅜-in. fillet welds. A completed main housing assembly weighs 2010 lb. Jigs and fixtures are used extensively in the process of fabrication. Allowable deviation from standard in this assembly is ±1/16 in.

The boring mill base shown in Fig. 3 was fabricated of rolled steel plate, bars and shapes and is 114 in. diameter and 43 in. high. The weight was held to only 6½ tons. Several fluid tanks were also welded into position.

In such cases welding is far less costly, is faster, can deliver rounded corners without machining to improve appearance of the finished tool. Coolant troughs, fluid tanks and other features can be more readily built integral with the tools.

In the hydraulic press shown in Fig. 4, heavy steel plate was employed, being formed on a 600-ton press brake. The entire structure was formed out of just two plates. Corners were rounded. All stress was relieved and the parts are annealed and blasted. Table plates were premachined. Completed frame contains leak-proof welded oil tank. These welded presses range all the way from 15 to 300 tons in capacity.

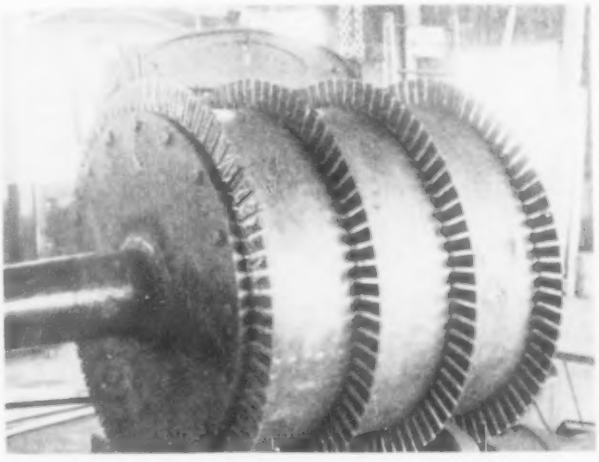


Fig. 5—Beater Roll for Paper Mill in Process of Fabrication

Figure 5 shows some beater roll as completed, with bars welded into position. This roll weighs approximately five tons, is 61 in. in diameter and has 62 bars, which are 54 in. long, 5 in. wide and $^5/_8$ in. thick, welded longitudinally around its circumference. The spider, which supports the structure, is made up of $^3/_4$-in. stock and the hub is $1^1/_2$ in. in diameter. The assembly is held together by 6200 in. of $^5/_8$-in. fillet welds. Distortion from heating is held to a minimum by having two operators work opposite each other at all points in the process of fabrication as shown in the picture.

Figure 7 shows an impeller for a marine pump in the process of fabrication. These units are made in sizes ranging from approximately 20 lb. each to 1300 lb. each. Such assemblies replace castings which were objectionable because large numbers were rejected when machining

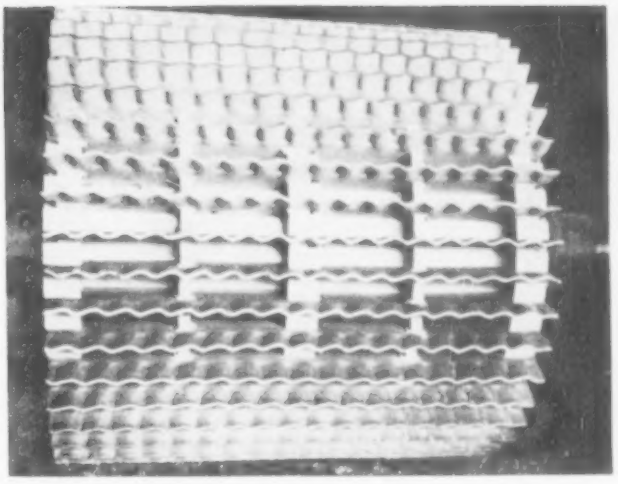


Fig. 6—Beater Roll for Paper Mill with Bars in Position

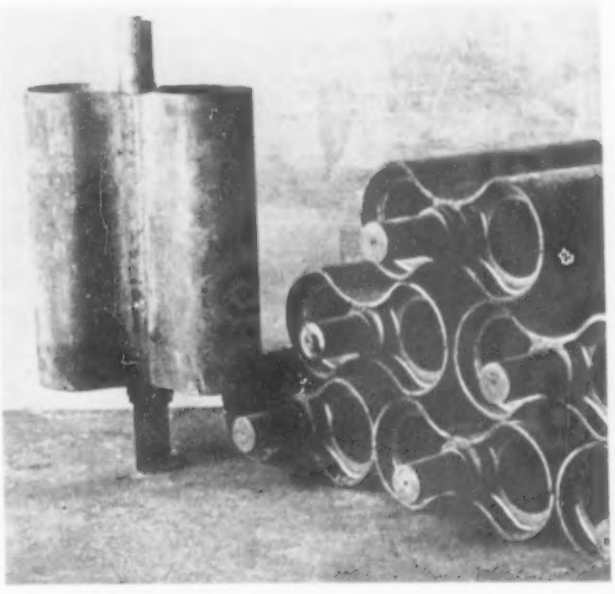


Fig. 7—Impellers for Marine Pumps. Sizes Range from 20 to 1300 Lb. Each

disclosed holes and imperfections. The average thickness of the welded material is $^1/_2$ in. These units are built to a very close limits as they must be dynamically balanced.

Magnetic Powder Inspection of Highly Stressed Welds, Castings and Forgings

By J. A. J. Long*

THE use of magnetic powder inspection on castings, forgings and welds is quite well known and is steadily increasing in use. It has several points which make it a valuable addition to any plant using castings, forgings or welding in the fabrication of highly stressed parts. It is inexpensive, a welding generator of 300 amp. capacity furnishes enough current for the general run of jobs. Certain cases require more current in order to show defects which may be well below the surface in a thick section. The fundamentals are easily learned; however, the beginner should use extreme care in interpreting the powder patterns, lest defects be found where no defects exist. It is non-destructive. When handled properly it can be used on finish-machined surfaces, without marring. If used on the rough casting, it saves many expensive and time-consuming operations.

Small, thin-walled steel castings or welded parts, not subject to high temperatures or high service stresses, can usually be accepted for service as is. Heavy steel castings, especially those intended for use in high-pressure steam and feed water installations, are known to have many defects as received from the foundry. These defects

* Leader Inspector of Ship Construction, Office of The Supervisor of Shipbuilding, U.S.N., Bath, Maine.

are hot tears, extensive shrinkage areas, cracks, sand inclusions, gas pockets and porosity. These defects can be very serious. Their detection and repair before installation are most important, not only from the purely economic point but, their failure in service could result in loss of life.

Two methods of applying the current are commonly used. The wrap method involves the use of long leads from the generator, which are wound around the object to be inspected, the current is then turned on and the powder is sprinkled on the area to be inspected and the pattern formed by the powder examined very closely. On very large objects, this method requires considerable time for wrapping as well as the use of crane service. The second method, which is much easier and faster, is the so-called "prod" or contact method and requires only two easily made "prods" of manganese bronze or copper about 1 in. in diameter and bent at right angles about 2 in. from the end to be used for contact; the "prods" are connected, one to each lead from the machine. The "prods" should be covered with an insulating material to protect the operator from shock and burns, since they become extremely hot after a few minutes' use. With this method, a switch should be connected to the generator field, so that the current may be shut off while the "prods" are being placed in contact with the object to be inspected, and again while they are being removed; otherwise the operator's eyes may be severely arc burned, and the casting badly pitted. In the case of high carbon or air-hardening materials this arcing could cause brittleness and cracking.

The accurate interpretation of the magnetic powder pattern is of the greatest importance. Failure to interpret correctly the pattern formed is worse than no inspection at all, since it results in existing defects being passed over, and on the other hand, areas that are not defective are needlessly excavated.

Cracks on the surface are easily determined. Subsurface defects, such as hot tears, porosity, non-metallic inclusions, require more experience and judgment. Some knowledge of foundry practice is very helpful in determining the type of defect shown by the powder pattern.

The depth below the surface at which defects will show in the powder pattern, cannot be predicted with any degree of accuracy. The variables involved are the degree to which the object being inspected is being saturated with current, the magnetic permeability of the object and its density. Fine cracks require very close observation and are easily overlooked if too much powder is sprinkled on at one time. Only enough powder to barely cover the surface should be used at one time. As soon as the defect is marked the loose powder should be blown off.

With the "prod" method, using 300 amp., the "prods" should be placed firmly on the object, and about 6 in. apart, the current then turned on, and the powder sprinkled lightly between the "prods," the pattern formed should be examined closely and the current then turned off. The loose powder should then be blown off. The "prods" should then be placed so that the next area will overlap the first by 2 in. This procedure should be followed in covering the entire object. When complete coverage has been made in one direction the process should be repeated with the "prods" at right angles to the first line of travel. This second coverage is necessary in order to pick up defects which run at right angles to the first direction of coverage, because the magnetic flux indicates those discontinuities which lie at right angles to its direction of flow.

In using this method of inspection on welds, it is necessary to grind smooth the weld surface in order to get accurate readings. Unfused sections are very easily detected.

On heavy castings, this method coupled with gamma ray gives gratifying results.

A good procedure to follow is—check with magnetic powder, gamma-ray defects indicated. If this procedure is followed, it will almost invariably be found that a crack shown by the powder comes off an extensive shrinkage area that will be shown by the gamma-graph.

Modern Welding and Structural Design

By Dr. Alois Cibulka*

THE art of welding as employed today in the structural field may be likened unto a beautifully developed Thoroughbred attached to a plow. Despite the misapplication, material savings of 5 to 15% over riveted types are realized from the present utilization of welding while with less effort savings of over 50% may readily be achieved.

Each new invention opens the way for other inventions. Portland cement made Steel Reinforced Concrete possible. Two entirely unrelated materials, steel and artificial rock, form a statical unity, providing mutual protection at the same time. In order to utilize the best qualities of each material, designers had to create new forms, new patterns. A tee section in reinforced concrete, where a wide concrete flange takes all the compression and the steel rods crowded in the narrow stem take all of the tension, is a classic example. The spiral reinforced column is another good illustration; there steel in tension prevents the concrete core from lateral spreading thereby increasing its compressive strength three to four times beyond its normal strength. In engineering, the question of material is important, but the "shape," the form, plays often the decisive role in the structural design.

Welding has made another invention possible which promises considerably in economy, strength and efficiency. "Reinforced Steel Timber" RST in general engineering principles is similar to "Steel Reinforced Concrete." Steel and Timber work together as a statical unity and protect each other against weather or fire hazards.

Wood exposed to rain and sun will rot; protected it lasts indefinitely. Piling under water, centuries-old roof-covered bridges, wooden objects from Pharaohs tombs of Egypt are good illustrations of wood durability when air changes are prevented from taking place around it or when sun and rain are excluded.

Hermetically sealed timber cannot change its moisture content; therefore will not check, crack or deteriorate. It is bulky yet light. Bulky sections have a large

* Engineer "R S T" Engineering Company, Highlands Texas.

radius of gyration "r," hence are ideal sections for columns or struts. Compression splices are easy to make in wood and can be made 100% efficient. Although wood burns it does not lose its carrying capacity when heated. In a fire, wooden columns and beams lose their strength only as their cross-sectional area is reduced by burning and in many respects are more fireproof than steel, especially so in cases of sudden hot flames. Wood is resilient, springy, a wonderful shock absorber. In most cases impact loads may be safely neglected.

Metals, by comparison, are not bulky and are inefficient as compression members, unless the material is concentrated about the periphery as in the case of hollow sections. Round pipe columns are good but are impractical for making connections. Although metals do not burn they lose their strength rapidly on heating. Metals last indefinitely if properly painted but the difficulty in maintaining a proper protective coat on present structures with their many corners and small clearances, presents a constant menace to their safety. Each construction material has its strong points and some weaknesses which make its use economical in one place and wasteful in another. A good structural design is one which endeavors to stress each material to its full 100% carrying capacity and, if necessary, uses a combination of different materials in the same structure to this end.

According to Hook's Law (not yet disproved since 1676 A.D.), in a composite section the load distributes itself to the individual parts in direct proportion to the moduli of elasticity and the corresponding cross-sectional areas.

Modulus of elasticity for steel $E_s = 30{,}000{,}000$ psi.
Modulus (average) of elasticity for timber $E_t = 1{,}500{,}000$ psi.

Thus in a composite structure of steel and timber, each square inch of steel will carry 20 times as much load as the adjoining timber. In concrete structures this relation varies according to the mix from $n = 6$ to $n = 15$.

For purposes of comparison, consider the favorite section of structural engineers, the rolled Bethlehem H Column, 14 WF weighing 426 lb. per foot and the welded "RST" box-type column as shown in Fig. 1. The "RST" column consists of a solid timber core, $21^1/_2$ in. square, encased in $^1/_2$-in. steel plates, stayed with bolts and welded together. Then

Area of steel $a_s = 44$ sq. in.
Area of timber $a_t = 462$ sq. in.
Weight of steel = 150 lb./lin. ft. Weight of timber = 130 lb./lin. ft. ($40^1/_3$ board ft. per lin. ft.)
Moment of inertia of steel shell, $I = {}^1/_{12}\,(22.5^4 - 21.5^4) = 3550$ in.^{4}
Radius of gyration of steel shell, $r = \sqrt{\frac{I}{a_s}} = \sqrt{\frac{3550}{44}} = 9$ in.

Allowable stress for structural timber in short columns (namely, length ÷ smallest side ≤ 11 is for select dense pine $f_t = 1450$ psi. In the case of "RST" the timber core is encased in a steel shell and, similar to hooped concrete, the stress could be much higher, but to avoid any argument, assume $f_t = 1250$ psi. For ease of computation, convert the area of steel into that of timber. Thus the composite "area,"

$$A_t = 20a_s + a_t = 20 \times 44 + 462 = 1342 \text{ sq. in.}$$

Theoretically the "RST" column would be good for a load,

$$L = A_t \times f_t = 1342 \times 1250 = 1{,}670{,}000 \text{ lb.}$$

if its length did not exceed $11 \times 22.5 = 20$ ft. But if $f_t = 1250$ was used for timber, the steel would be stressed 20 times as high or 25,000 psi. Assume the allowable working stress for steel to be $f_s = 17{,}000$ psi. Then, the working stress for timber can be only

$$f_t = \frac{17{,}000}{20} = 850 \text{ psi.}$$

and the safe column load is reduced to,

$$L = 1342 \times 850 = 1{,}140{,}000 \text{ lb.}$$

This is not a misfortune but rather an advantage that may be exploited in several ways:

First Choice.—It may be used as fireproofing for the column. In fire, the steel shell softens, its modulus of elasticity decreases while that of wood remains the same. Thus the timber core gradually takes over all of the load. The steel shell relieved of its load does not collapse but remains stayed by the bolts with the column. The

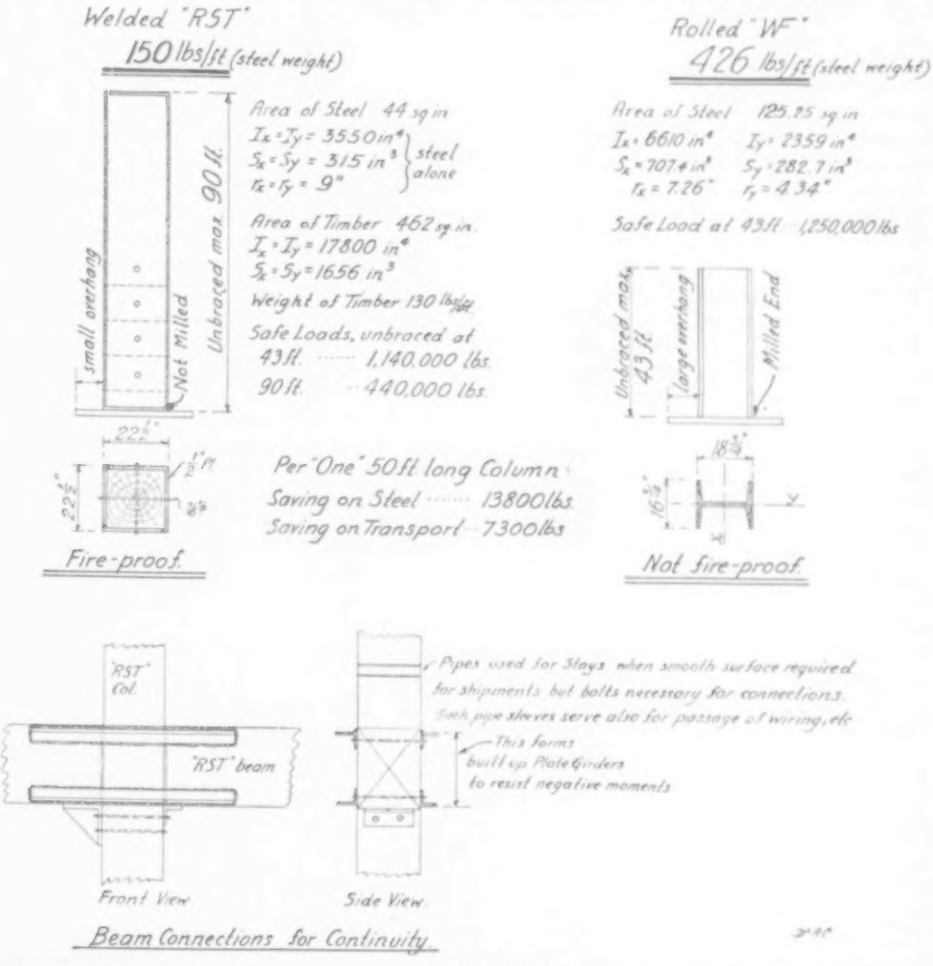

Welded "RST"
150 lbs/ft (steel weight)
Area of Steel 44 sq in
Ix = Iy = 3550 in⁴
Sx = Sy = 315 in³
rx = ry = 9"
steel alone
Area of Timber 462 sq in.
Ix = Iy = 1780.0 in⁴
Sx = Sy = 165.6 in³
Weight of Timber 130 lbs/ft
Safe Loads, unbraced at
43 ft. ..... 1,140,000 lbs.
90 ft. ..... 440,000 lbs.
small overhang
Not Milled
Unbraced max. 90 ft.
22½"
½" PL
22½"
Fire-proof.
Per "One" 50 ft long Column
Saving on Steel ..... 13800 lbs.
Saving on Transport 7300 lbs
Rolled "W"
426 lbs/ft (steel weight)
Area of Steel 125.25 sq in
Ix = 6610 in⁴
Iy = 2359 in⁴
Sx = 707.4 in³
Sy = 282.7 in³
rx = 7.26"
ry = 4.34"
Safe Load at 43 ft. 1,250,000 lbs
Unbraced max. 43 ft.
Large overhang
Milled End
18¾"
16¾"
Not fire-proof
"RST" Col.
"RST" beam
Front View
Side View
Pipes used for Stays when smooth surface required for shipments but bolts necessary for connections. Such pipe sleeves serve also for passage of wiring, etc.
This forms built up Plate Girders to resist negative moments
Beam Connections for Continuity

Fig. 1—Comparison Between Welded "RST" Columns and "Rolled" Columns.

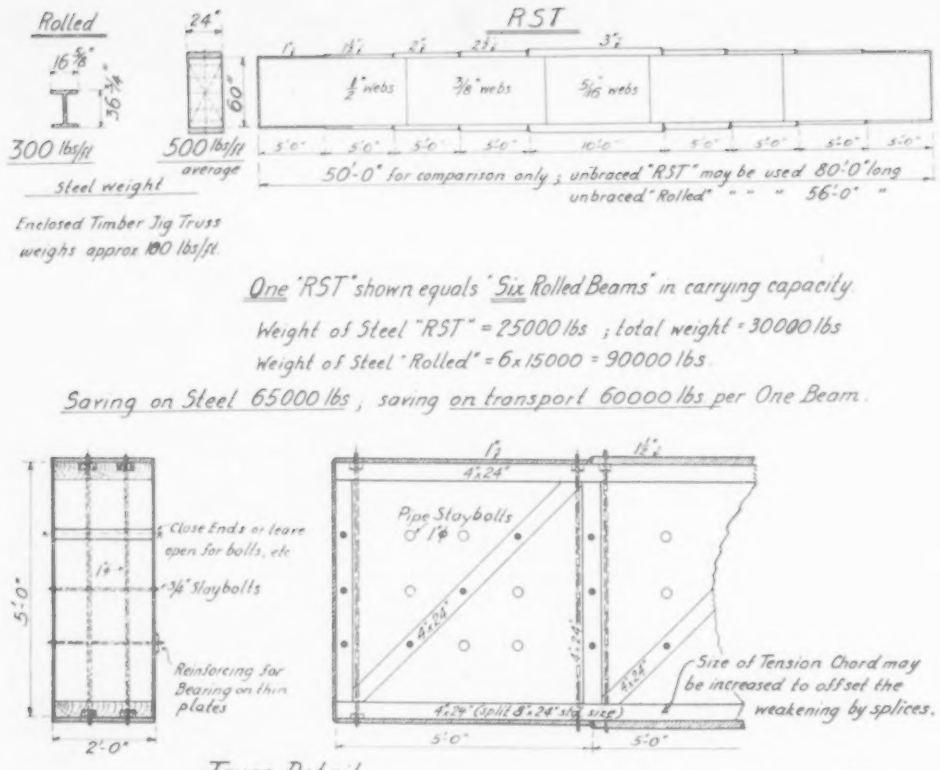

Rolled
RST
24"
16 5/8"
36 3/4"
60"
300 lbs/ft
500 lbs/ft
average
Steel weight
Enclosed Timber Jig Truss
weighs approx 100 lbs/ft.
1/2" webs
3/8" webs
5/16" webs
5'-0"
10'-0"
50'-0" for comparison only; unbraced "RST" may be used 80'-0" long
unbraced "Rolled" " " " 56'-0" "
One "RST" shown equals "Six Rolled Beams" in carrying capacity.
Weight of Steel "RST" = 25000 lbs ; total weight = 30000 lbs
Weight of Steel "Rolled" = 6 x 15000 = 90000 lbs
Saving on Steel 65000 lbs, saving on transport 60000 lbs per One Beam.
Close Ends or leave open for bolts, etc
1/4"
3/4" Staybolts
5'-0"
Reinforcing for Bearing on thin plates
2'-0"
Pipe Staybolts of 1" ϕ
4"x24"
Size of Tension Chord may be increased to offset the weakening by splices.
4"x24" (split 8"x24" size)
5'-0"
Truss Detail.
Note: Some Codes permit higher stress for compression than for tension welds.
This leads to unsymmetrical sections.
Compression flange as a column should have a lower stress in any case and
it is safer to design symmetrical sections based on the lower tension value.

Fig. 2—Comparison Between Welded "RST" and the Largest Rolled Beam

timber positively sealed cannot burn. As illustrated in the calculations above, the wood is capable of supporting a permanent load of 462 × 1250 = 570,000 lb. It may be overloaded for a short period of time two to three times with safety. Assuming a double load such a fireproof column will carry 2 × 570,000 = 1,140,000 lb., which is the full load for which it was designed.

In saving the wood from burning, the steel is prevented from collapsing by having the unburned timber core assume full responsibility for carrying the load. The column is thus fireproofed. There is no necessity for an outside covering that only adds to the dead weight and occupies valuable space. The only damage which water played upon the column in the fire fighting will cause, is a blistering and subsequent loss of the paint, which can easily be repaired.

Second Choice.—The reduced value $f_l = 850$ for the timber column corresponds to the ratio $l/d = 23$. Therefore an "RST" column needs no bracing until its length exceeds 23 × 22.5 in. or 43 ft. and carries its full load of $L = 1{,}140{,}000$ lb. It may be used unbraced to a height of $50d$(50 × 22.5 in.) 94 ft. and if it is considered as a composite section with an allowable $f_t = 172$ psi. at that ratio it will theoretically carry a load,

$$L = 172 \times 1342 \text{ or } 230{,}000 \text{ lb.}$$

Third Choice.—In long "RST" columns [beyond 60 ft. in length in this particular case] it is advantageous to neglect the timber core entirely and only consider the steel shell. A box-type steel shell alone has a radius of gyration equal to 9 in. and for $l/r = 120$ it can be used unbraced up to a length of 90 ft. With an allowable steel stress of 10,000 psi. this column is capable of a load,

$$L = 44 \times 10{,}000 \text{ or } 440{,}000 \text{ lb.}$$

Actually the wood core also participates in carrying the load and the stress in the timber is equal to 10,000/20 or 500 psi., which is not excessive, for the steel shell acts in the same manner as hoops in spiral reinforced concrete columns, and, after all, the timber was not included in calculations at all.

The economy of "RST" columns is readily apparent. Approximately 65% of the steel normally required is saved; 34% less total dead weight; no external fireproofing; painting surface reduced by 10%; and the shock resistance for earthquake-proof buildings is far greater than with current steel or reinforced concrete structures. Nearly 7 tons of steel are saved by using one 50-ft. "RST" welded type column instead of rolled sections. In addition to this fact, connections to WF are difficult to make while "RST" offers flat surfaces, easily accessible to welders. The welded-in construction bolts serve several purposes: (1) they securely fasten the plates to the timber jig thereby facilitating the welding operation; (2) they act as staybolts for the plates, serving similarly to the lattice bars of built-up columns and may be calculated as such for a 2% column load; (3) they may be used for bolted connections, clips, seats, etc.; (4) they may be used to reduce the stresses of welded connections due to eccentricity in loading; (5) these bolts may be utilized to support any desired outside covering for the columns. Continuity of beams is simply achieved with "RST" columns. Side plates or side angles welded to beams and columns may be proportioned to suit the negative moments. The column plates act as webs for such built-up beams; the statical properties of these composite beams are easy to determine.

Figure 2 shows a typical "RST" girder as compared with widely used heaviest rolled sections 36-in. WF, 300 lb. per foot. The wooden jig is formed as an independent truss capable of supporting a considerable load by itself. The projecting bolts serve the same purposes as described above with columns (besides acting as members for timber truss). The depth and width of "RST" beams may be varied at will to accommodate the availability of steel plates, timber, clearances, etc. Thin cover plates instead of thick plates may be used for flanges and the web thicknesses are varied to meet the shears encountered. Staybolts replace the familiar stiffeners of built-up girders at far less cost, less labor and with far better stress distribution. "RST" beams have a great section modulus for lateral thrusts and are the best obtainable for railroad bridges, crane runways, supports for vibrating machinery and other shock loads.

Figure 3 is an interesting application of "RST" welded

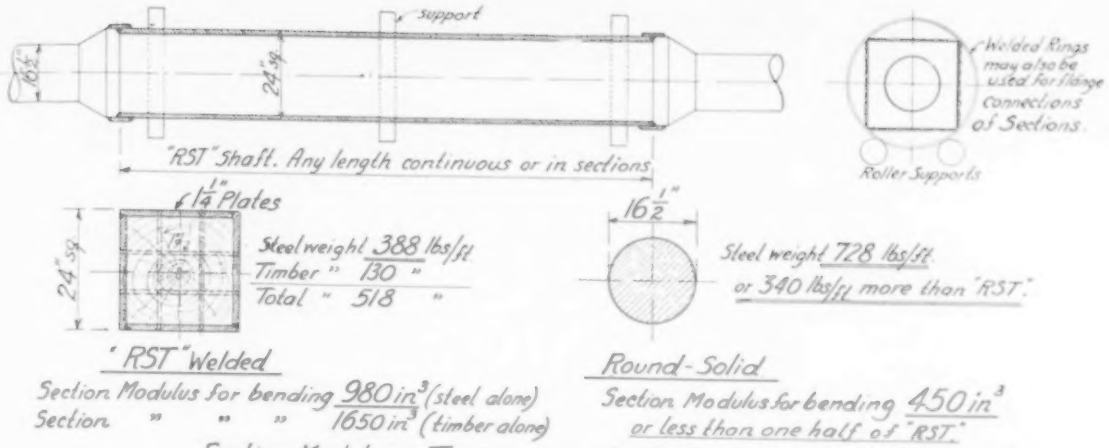

Support
16½"
24" sq
"RST" Shaft. Any length continuous or in sections
Welded Rings may also be used for flange connections of Sections.
Roller Supports
1¼" Plates
24" sq
Steel weight 388 lbs/ft
Timber " 130 "
Total " 518 "
16½"
Steel weight 728 lbs/ft
or 340 lbs/ft more than "RST."
"RST" Welded
Section Modulus for bending 980 in³ (steel alone)
Section " " " 1650 in³ (timber alone)
Round-Solid
Section Modulus for bending 450 in³
or less than one half of "RST."
Section Modulus in Torsion is practically equal ~ steel considered only.
Lighter and Stronger in bending "RST" Shaft has smaller Deflection and less Vibration. It can be repaired in place by Welding on Cover Plates.

Fig. 3—Comparison Between Welded "RST" and Solid Round Shaft for Ships

sections. The present round shafts for ship propulsion are one of the most expensive items in ship building. Because of their excessive weight, round shafts are made in short lengths with bulky overlapping flange connections. Repairs to damaged shafts are difficult to make and very costly. The "RST" welded shaft is lighter, stronger, cheaper and easy to repair. It is also made in sections, which are statically and dynamically balanced and joined by special couplings of inexpensive construction.

Figure 4 illustrates an "RST" design of a railroad bridge, truss-type. Bridges, arches, structures of unusual dimensions, earthquake- and fire-proof structures are economically feasible with "RST" welded designs.

In the September 1943 issue of THE WELDING JOURNAL, there is an excellent article by H. Malcolm Priest entitled "The Practical Design of Welded Steel Structures." On 34 pages there is presented to the structural engineers a wealth of information about welded structures not to be found in books many times its size. For "RST" designers it is worth while of careful study for comparison.

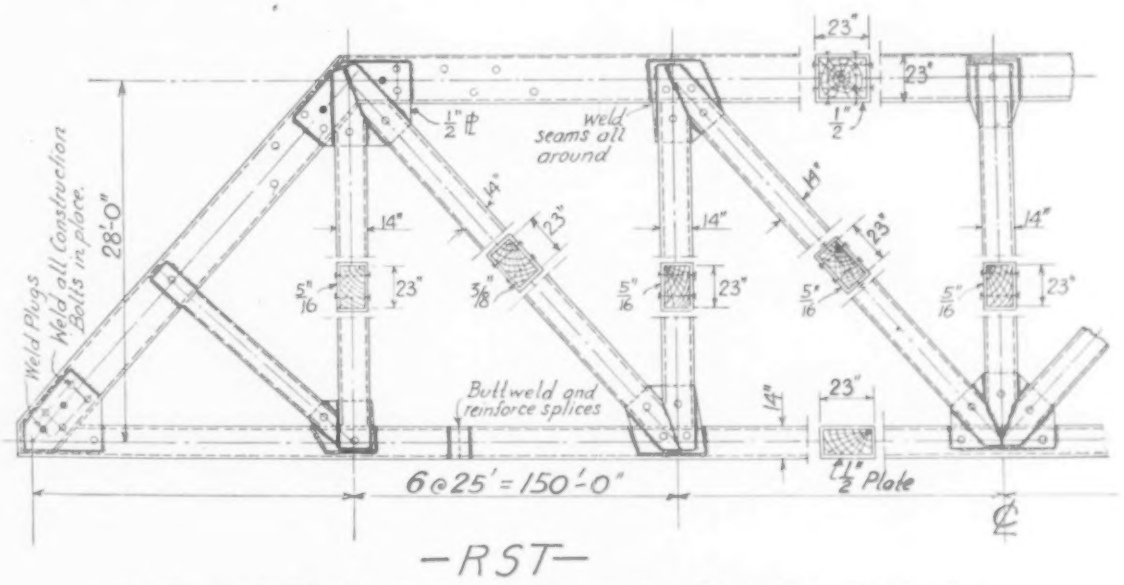


Fig. 4—Single Track Bridge Truss for Cooper's E-50 Loading. Span 150 Ft.

Current Welding Literature

(Continued from page 107)

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Electric Welding Machines, Control. Automatic Voltage Compensator for Resistance Welding Control, E. M. Callender and R. S. Phair. Elec. Eng., vol. 62, no. 11 (Nov. 1943) (Trans), pp. 701–705.

Electric Welding Machines, Control. Automatic Welding-Machine Starter and Its Relation to Maximum Utilization of

(Continued on page 134)

Automatic Arc Welding Solves Production Problems*

By R. F. Wyer†

In order to narrow this discussion down to manageable dimensions, let us confine the detailed references to applications involving metal arc and atomic-hydrogen arc welding. The points of interest in connection with automatic welding with the metal arc, using bare and lightly coated electrodes or shielded arc electrodes, and atomic hydrogen arc welding, will pretty generally apply as well to carbon arc, helium and argon shielded arc, or submerged melt automatic welding.

Incidentally, I may be out of order entirely in referring to this general subject as automatic welding. Perhaps you would prefer to stay in line with A.W.S. nomenclature and call it machine welding. Whatever it is called, I think the process will be recognized as we touch briefly on the various types of equipment and typical applications, discuss some general application factors, and look into the matters which must be dealt with in order to take best advantage of automatic arc welding.

Automatic arc welding today pretty generally involves two main factors: first, the establishment, by means of rotating or traveling fixtures, of a constant speed of the arc relative to the work; second, the control of the voltage of the arc, to keep it uniform, and thus to maintain a uniform and proper physical arc length. This control of arc length in response to arc voltage changes can be accomplished by a number of means—by mechanical clutches or variable speed transmissions, by motor armature speed control, by motor field control, by generator field control, or by electronic control schemes. All the equipments specifically referred to in this paper employ electronic control of the welding head motor.

Figure 1 shows a typical electronically controlled automatic arc welding head. It is both a motor-driven wire feeder, and an arc voltage regulator. Thus, it can be used for maintaining an arc between an electrode and the work while feeding the electrode into the arc which consumes it, or it can be used to maintain an arc of the correct length when a relatively permanent electrode, such as a tungsten or carbon rod, is used. As a plain wire feeder, it may also be used to feed wire into an arc at a pre-set rate or at a rate controlled manually.

As most commonly used, this machine feeds electrodes from a continuous coil into the arc, at the proper rate to maintain a practically constant arc length. Welding current is introduced into the electrode by the current collector, or nozzle, at the bottom of the assembly. As soon as the proper control push-button is pressed, the welding head advances the electrode toward the work until a short circuit occurs between the electrode and the work, then withdraws the electrode to establish an arc.

Whereas an operator doing manual welding uses the appearance of the molten pool of deposited metal, and the sound of the arc, to judge the correct arc length, this machine uses the voltage drop across the arc to measure the arc length. As a voltage regulator, it responds to slight differences between the actual arc voltage and the desired arc voltage, and thus maintains the two approximately equal.

This type of welding head can be used to feed bare wire in submerged melt welding (Fig. 2), or to feed bare or lightly coated electrodes in metallic arc welding.

Slightly modified (Fig. 3), the same head will feed short lengths of heavily coated electrodes, or it will maintain an arc (Fig. 4) between a tungsten or carbon electrode and the work—in this case in an atmosphere of helium or argon. Another similar welding head can be used to feed filler wire (in this case, magnesium) through a wire guide, as shown at the left.

A further modification of the same basic design results in an automatic head (Fig. 5) for feeding heavily coated electrodes from a continuous coil. In this machine, four rubber-tired feed rolls are used to prevent crushing the coating of the wire, and a motor-driven circular saw is used to slit the insulating coating of the electrode down to the core wire. Through the slit thus produced, six contact fingers convey the welding current into the electrode, near the arc.

An entirely different type of welding head (Fig. 6), still working on the voltage regulator principle is used to maintain an arc between two tungsten electrodes in atomic-hydrogen arc welding. Here the wire-feeding function is confined to very slow motion to compensate for extremely slow consumption of the tungsten electrodes which would otherwise gradually lengthen the arc.

The same basic considerations which guide the selection of one process and electrode or another for a given application, apply in automatic arc welding as in hand welding. The metal arc using bare and lightly coated electrodes is used in the automatic welding of such things as water tanks, automotive frames and axles, housings, practice bombs, and couplings.

Automatic equipment for feeding individual sticks of heavily coated electrodes is usually applied to work where one complete joint can be welded with one stick of electrode. Thus the stick feeder is usually used on small work, such as containers, casings, bombs, shells and machine gun water jackets, rather than to large parts having long joints. Typical is the application shown in Fig. 7—a stick electrode feeder used in the welding of refrigerator float valve chambers. Here an edge weld was made, joining two pieces of $^1/_{16}$-in. material at a rate of speed which was not extraordinarily high, but which was maintained, hour in and hour out, to achieve a very high daily output. Rejects on this job, incidentally, were almost incredibly low, far under 1%—and each unit was given a 200-psi. leak test.

One of the particularly valuable characteristics of this

* Presented at the Annual Meeting, A.W.S., Chicago, Ill., Oct. 18 to 21, 1943.

† Application Engineer, General Electric Co.

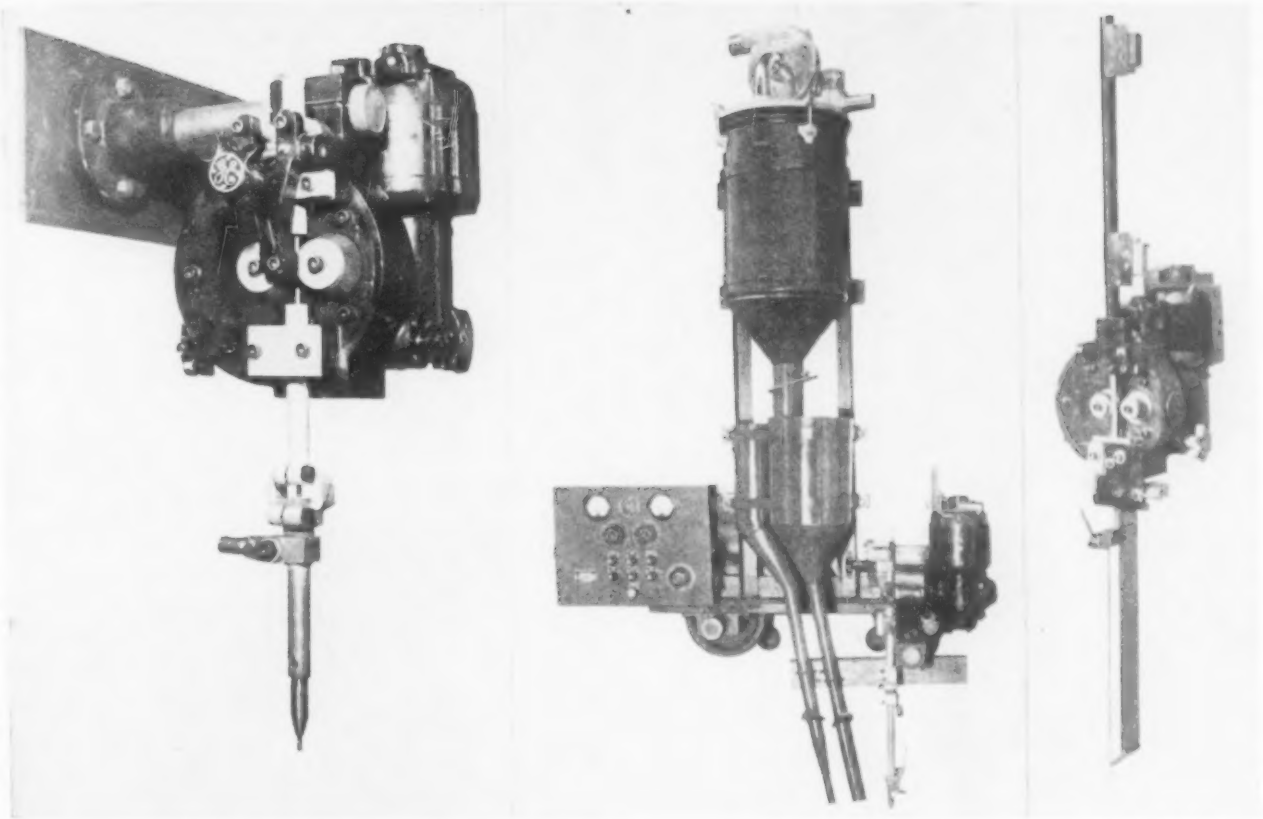


Fig. 1 Fig. 2 Fig. 3

Fig. 1—Essentially a Gear-Motor Driven Wire-Feeder, This Arc Welding Head, with a Thyratron Control Panel, Is Used for Automatic Welding with Bare and Lightly Coated Electrodes

Fig. 2—The Arc Welding Head of Fig. 1, Mounted on a Travel Carriage with Melt-Hopper and Melt-Recovery Unit, Is Used for Submerged-Melt Welding

Fig. 3—Stick-Electrode Feeding Device for Arc Welding

type of equipment is that it permits the use of any heavily coated electrodes in short lengths. Since standard hand welding electrodes are used, the limitation sometimes encountered in securing the proper analysis of core wire or coating in coiled electrodes is largely avoided.

When long seams are required to be made with shielded arc welding, equipment such as this may be used to advantage (Fig. 8). Here a welding head, for feeding heavily coated electrodes in coils, is mounted on a gantry-type travel mechanism, providing adjustment of the vertical height of the welding head, and its lateral position, as well as providing uniform traverse along straight joints. This particular equipment is usually used with a rotating device, so that circumferential seams can be made by holding the welding head stationary while the work rotates beneath it.

Such equipment is used for putting in higher quality welds on such products as boiler drums, refinery equipment, combat tank wheels, and highly stressed rotating parts.

Automatic atomic-hydrogen arc welding heads are used almost exclusively on jobs which do not require the addition of filler metal. Typical of such work is the welding of Bren machine gun cartridge clips, making a butt joint on 0.035-in. steel. Figure 9 shows another typical application of automatic atomic-hydrogen arc welding. Here an inconel tube, about $^{3}/_{8}$ in. diam., is being welded at speeds up to 60 in. per minute. Enormous quantities of thin-walled tubing in stainless steel are also welded this same way. Pressure accumulators and oxygen cylinders for aircraft are other typical examples.

Instead of cataloging a large number of applications, and giving the statistics on each, it would seem to be more helpful to consider general application factors to see how automatic arc welding *can* be used, rather than to prove that it *has* been used.

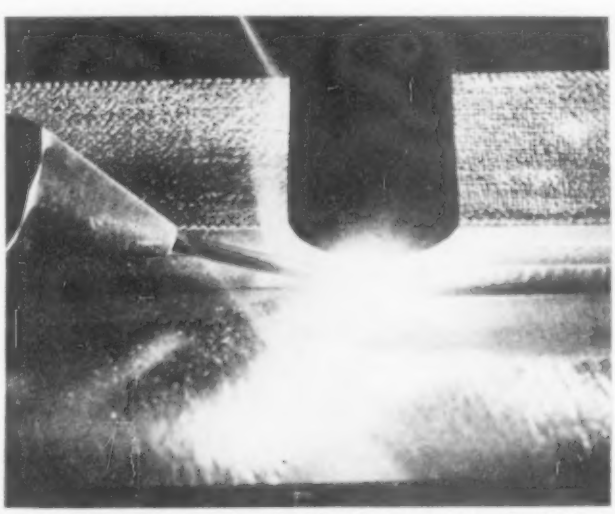


Fig. 4—In Helium-Shielded Arc Welding, Thyratron Controlled Automatic Equipment Moves Electrode and Gas Nozzle to Maintain Proper Arc Length and Gas Shield, Even in Welding on Inclined Seams

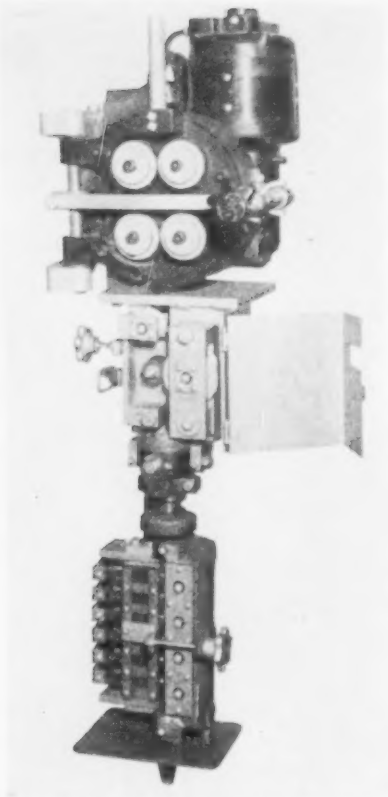


Fig. 5—Automatic Arc Welding Head for Continuous Lengths of Heavily Coated Electrodes Includes Saw for Slitting Coating, and Contact Fingers to Introduce Welding Current Into Core Wire

The choice of automatic arc welding versus manual arc welding is largely one of economics. Assuming that the economics of a case favor automatic welding, it should be applied if the product will stand it. To be suitable for automatic welding, the joint must be positioned for flat or horizontal fillet welding. It must be uniform as regards joint preparation. This uniformity should apply not only to a specific joint, but should carry over from joint to joint. That is to say, it is not enough that one joint have good fit-up, and the next piece have passable fit-up; in order to get the best advantage from automatic welding, each piece should be as good as the one before it. If adjustments to the arc length, travel speed, welding current, or angle of the electrode have to be made to suit the individual joint in question, then there is grave doubt whether automatic arc welding will be practical, except possibly in the case of very long seams where each represents a considerable portion of a day's operation.

One other nearly universal requirement is that the work be regular in shape. Obviously straight seams and perfectly circular work lend themselves to automatic welding much better than joints which have to be followed

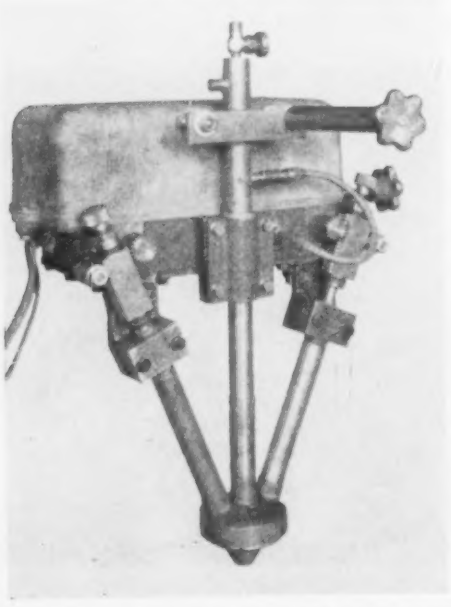
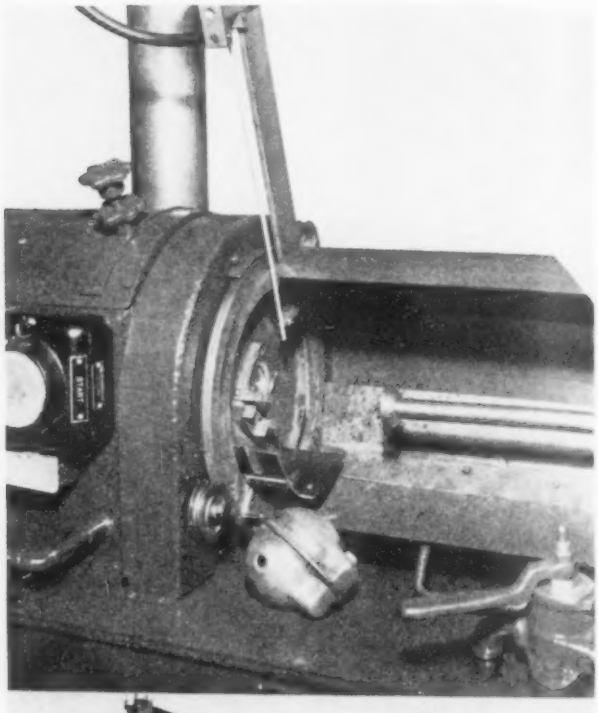


Fig. 6—Automatic Atomic-Hydrogen Arc Welding Head Adjusts Two Tungsten Electrodes to Maintain Uniform Arc Voltage

Fig. 7—Pre-War Application of Automatic Stick Electrode Feeder, for Welding Refrigerator Float-Valve Chamber (Shown on Bed-Plate of Machine)



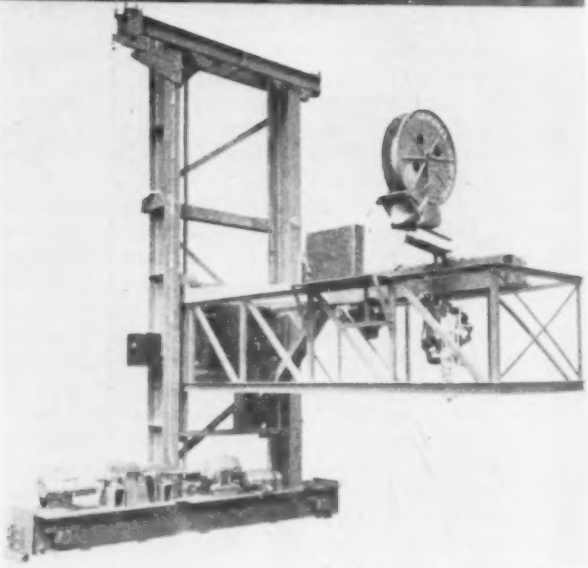


Fig. 8—Automatic Arc Welding Machine as Used in Fabricating Boiler-Drums and Pressure Vessels

in irregular paths. Irregular shapes can be handled, however, in cases where it is desirable. For instance, gasoline tanks of very irregular shape have been welded automatically, using a template to guide the work, supported on a castered dolly, so that the joint stayed always under the arc. In the case of the refrigerator float valve chambers shown in Fig. 7 the chamber was not circular in section. In this case, cams were used in the welding fixture to shift the centers about which the work was rotated, keeping the electrodes practically radial to the curved sections and at right angles to the straight sections of the joint.

Of course, some production requirements will dictate the use of automatic arc welding even where the economic advantage is not too obvious. For example, some joints, particularly on very thin stock, cannot be done reliably enough by hand, whereas the job will be perfectly practical with automatic equipment, even though an analysis based on travel speed per individual unit, and including fixed charges on automatic equipment, may make the cost appear to be higher than that of hand welding. Likewise, some labor and training problems can be eliminated or minimized by the use of automatic arc welding heads, operated by women or relatively unskilled labor, to produce work having such exacting demands as to quality and effort as to require otherwise the use of only the most skilled hand welding operators.

Along this line of thought, consideration should be given to the possibility of operating two jobs with one attendant who can be unloading, loading and starting one machine while the other is welding.

The basic advantages of automatic arc welding are speed and uniformity. Except in cases where extremely thin material makes hand welding difficult, very large increases in actual travel speed of the electrode should not be expected when comparing automatic arc welding with hand welding. Unless the process itself is changed, as in substituting submerged melt welding for shielded arc welding, the adoption of automatic equipment does not usually result in any very large increase in the actual arc travel speed. This is because, with hand welding, the travel speed is set more by the amount of heat which can be successfully applied to the joint, and by the current density which can be withstood by the electrode without sacrifice of performance, than by any limitation in the speed with which the operator can move the electrode.

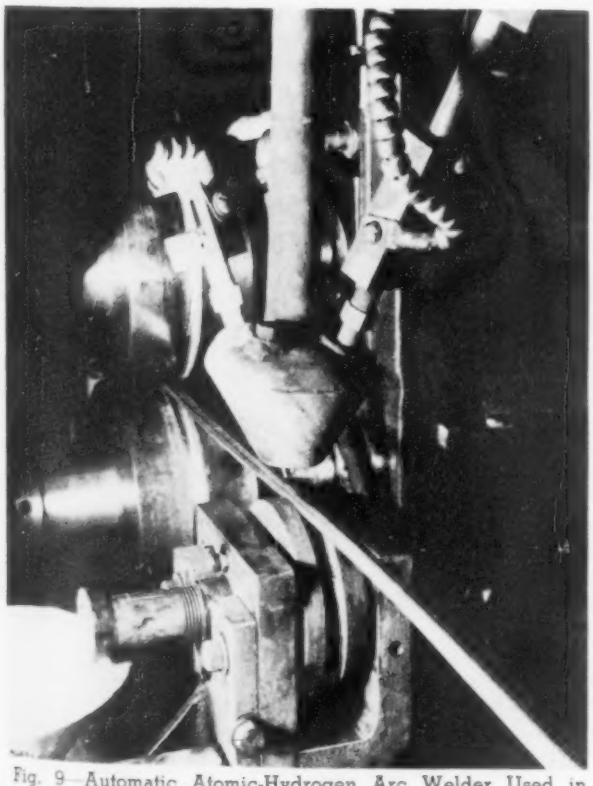


Fig. 9—Automatic Atomic-Hydrogen Arc Welder Used in Welding Inconel Tubing

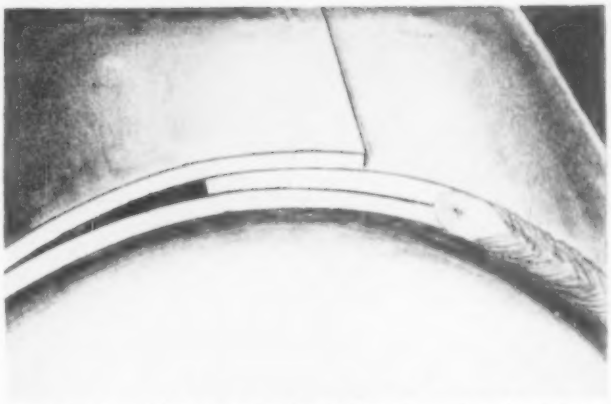


Fig. 10—Lap Joints in Cylinders Often Cause Trouble When Circumferential Joints Are Being Welded

Usually, however, *some* increase in speed can be obtained by using higher current with automatic equipment feeding coiled electrodes, because the current for welding is introduced into the electrode very near the arc. Since the electrode has to move only a relatively short distance from the nozzle to the arc, it is carrying the welding current for only a very short time, and consequently does not heat up so much as in the case of manual welding, where the electrode holder end of the electrode must carry the welding current for as long as a minute and a quarter. Thus the current density in the electrode can often be increased without seriously affecting the performance of the electrodes due to overheating.

The very uniform and close control of the heat input to the work will also frequently permit some increase in the welding current. The increased rate of heat input is then counteracted by an increase in the travel speed, so that the work can often be done at a somewhat higher arc travel speed.

Thus, in cases where the hand welding speed is limited by the current density in the electrode or the limit of heat capacity of the work, *some* increase in speed may be expected through automatic welding. Usually this increase is in the range of 10 to 20%. Only in the case where the travel speed in manual welding is limited by the operator's inability to move accurately at higher speeds can a startling increase in speed be reasonably expected from automatic welding.

The important increase in production obtainable through automatic arc welding does not really come, except in rare instances, through the increase in arc travel speed alone. The most obvious contribution to increased production speed comes from the reduction of operator fatigue. This is a pretty hard thing to evaluate, but it is not at all unusual to find that the over-all production on a manually welded job, even where rotating fixtures are used, is about half what would be expected from the floor-to-floor welding time measured in the morning. The only conclusion is that fatigue prevents the operator from keeping up his morning rate all day long.

Still harder to evaluate, but none the less important, is the pacing effect of automatic welding. With the definite, simple set of motions, repeated at regular intervals, required of the operator of an automatic arc welding equipment, the rhythm of rapid, steady production is

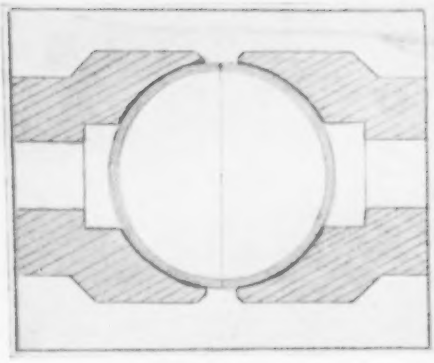


Fig. 11

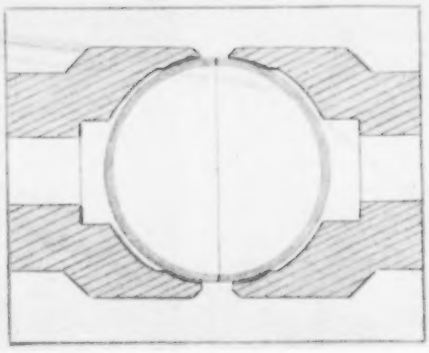


Fig. 12

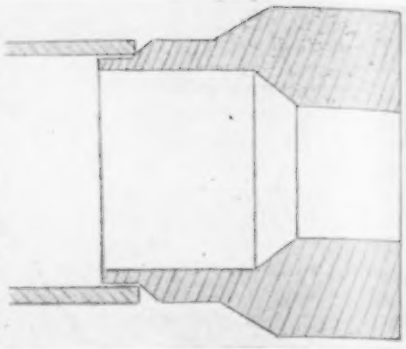


Fig. 13

Fig 11—Chucking a Sphere This Way Gives Trouble Because of Uncertain Heat Flow
Fig. 12—Gripping Plates Near the Seam Facilitates Uniform Welding
Fig. 13—Joint Design Can Give Good Backing

more easily established than when the bulk of the work must be done with intense concentration by the operator himself.

The other main advantage of automatic arc welding—uniformity—is fairly obvious, and has obvious implications as regards the cost of operation. If rejects and rewelding can be completely eliminated, as is virtually the case in a good automatic arc welding application, the over-all standard of quality can be increased, and the total output of the job is often increased as well. The quality of the metal deposited with the automatic equipment is not necessarily any better than that of metal deposited manually. The important point is that it is *uniform* in quality. To put it another way, the quality is not better than *can* be produced with hand welding, but taken over a day's operation, it is usually higher than *will* be produced in hand operation.

Of course, the advantages in automatic welding presuppose proper preparation of the joint and other good conditions for welding. It might be put this way: It will pay to improve the joint design, and the fit-up of parts for arc welding if you can be sure that the effort and possible expense involved in these changes will not be nullified by variations in the welding technique. Establishment of automatic arc welding guarantees that the benefits of good and uniform design and fit-up will be realized in better and faster production.

This leads to a consideration of design for automatic arc welding. There are many possible approaches to the subject. Considerations involving metallurgy, the strength of the joint or the economics of one joint design over another, however, are little affected by the choice of automatic or hand arc welding.

But approaching the subject from what might be called the heat-balance point of view has possibilities in clarifying the problems and simplifying the thinking involved in making the best use of automatic arc welding.

The factor most clearly differentiating automatic from manual arc welding is the uniformity of the rate of heat input to the joint. This basic factor demands attention from the designer. It is evident from many of the designs proposed for automatic applications that this consideration is too often given little or no attention. It is the old story of welded products being designed with proper regard for every factor except the all-important one . . . how are you going to weld it?

In automatic arc welding, rate of heat input, in energy units per second of time, is uniform. Automatic arc voltage controls maintain constant average arc voltage. If the current setting of the welding power source is unchanged during welding, which is usually the case, the arc current is substantially constant because the load voltage on the welder does not change. Since the energy in the arc is determined by the product of arc voltage and amperes, it is constant. That is to say, constant volts times constant amperes equals constant watts.

Of course, not all the energy dissipated in the arc goes into the joint. But with the controlled arc length of automatic welding, the amount of heat lost to the atmosphere, or to the surrounding gas or flux, by conduction, convection and radiation is approximately a constant. Thus, the net heat input to the joint is very nearly constant, as measured by watts, or watt seconds per second.

The speed of travel of the arc with respect to the joint is almost of necessity constant in automatic welding. Here is a big difference between manual and automatic arc welding. The operator in hand welding watches the contour of the molten pool of weld metal, and varies the speed of travel (as well as the length of arc and angle of electrode) to control its size and shape. But the traverse mechanism in machine welding goes on at a uniform rate, as measured, say, in inches per second. So the arc delivers heat at a constant rate of watt seconds per second, and it traverses the work at a constant rate of inches per second, and dividing the heat rate by the travel rate, gives a constant value of watt second per inch of joint. That is, the heat energy put into an inch of joint is uniform.

This concept holds just as true for atomic hydrogen automatic arc welding as for metal arc, carbon arc, or submerged melt weld. The averages of arc voltage and current are still constant. The adjustment of arc position with respect to the work is constant, so the efficiency of heat transfer and the net heat input to the work are constant. So is the travel speed, and again the heat input per inch of joint is uniform.

All this uniformity in heat input to the joint suggests the desirability of uniform heat outflow from the welding area. The input and outgo of energy measured over the time for fusion and solidification must be equal at all points in the joint if uniform welding is to be accomplished. The time lag between heat input and heat outgo at a given point will determine the peak temperature which is reached at that point. The balance between heat input rate and heat outgo rate is thus a critical one, and has many mechanical effects besides its effect on the metallurgy of the joint.

The depth of fusion, for example, will be affected. So will the support afforded the molten pool or the degree to which backing of the joint is found necessary. Likewise, the size of the weld, its contour and appearance, undercutting and slag coverage, all will be dependent on heat balance.

The evidence is, then, that the rate of heat outgo must

be uniform from point to point in the joint, if the welding is to be uniform. This is mainly up to the designer. For the design of the joint and the parts adjacent to it controls the heat flow to a large extent.

Besides the heat conductivity of the material, the thickness of the stock will affect the rate of heat transfer away from the joint. To keep the latter uniform, therefore, you must have uniform plate thickness. Avoid any automatic welding where the section is changed along the way, either in the actual fusion zone, or adjacent to it. Attempting to cross previous welds or lap joints in the plate, for example, very frequently gives trouble in this respect. Figure 10 shows a typical joint, which comes up frequently, involving a head welded into a cylinder having a lap joint, either fusion or resistance welded. Sometimes this head is convex, and a fillet weld is required; sometimes it is concave, calling for an edge weld as shown. In either case, trouble will frequently arise when the lap is reached, no matter how carefully it is jogged to improve fit-up, because of the change in heat capacity at the lap. The same example also illustrates a case where fit-up has a bad effect on heat balance. Unless very carefully fitted, the gap between outer and inner plates near the lap causes heat balance trouble not only because of the thermal capacity change, but because the heat conductivity between plates is very poor at the lap, while very good at other places. A better design uses a butt joint in the cylindrical piece, thus eliminating both the radical change in section and the likelihood of poor fit-up.

The same consideration of thermal conductivity and balance can lead to sound design for automatic welding where clamps and jigs are used. Frequently, clamps perform not only the function of holding plate edges securely in alignment, but also of providing cooling means to control or limit the flow of heat through the plates. It is essential that the heat flow characteristics of the clamps be constant in automatic arc welding. This means that the clamping device should be carefully considered in the design of the parts to be welded, with due regard for the warping and expansion which will occur when the heat of the arc is applied.

In a job, for example, involving the clamping of two hemispheres for the welding of a butt joint (Fig. 11), it might be assumed that best results would be obtained if the clamps contact the work over a wide area, as shown. This is not true, however, since it is impractical to get zero tolerance in the stampings forming the hemisphere. There are bound to be variations in the point of contacts of the clamps with the work. Moreover, the expansion of the metal of the clamps as they heat and cool will produce slight distortion in the clamps, with similar results. This inevitably means a change in the length of the path of heat flow through the plates from the fusion zone to the clamps, with consequent uneven depth of fusion and uneven cooling rates.

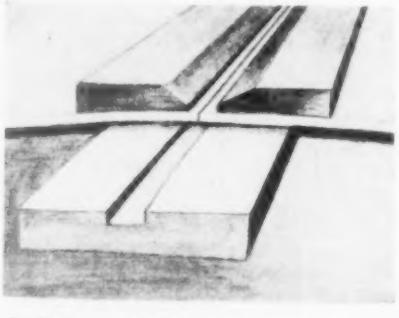


Fig. 14.—A Grooved Chill Bar Permits Backing Atomic-Hydrogen Arc Welds with Hydrogen Gas

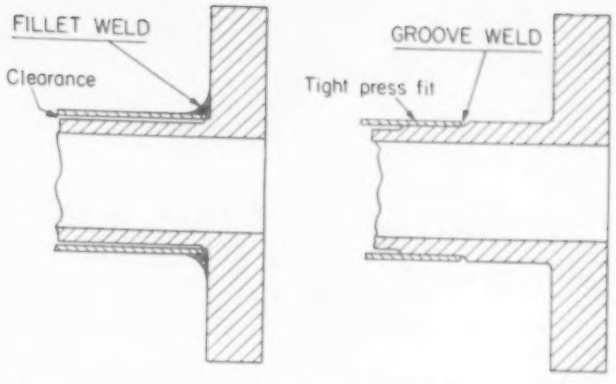


Fig. 15—Better Heat Balance Is Obtained in the Design at the Right, by Keeping the Weld Away from Junctions of Light Sections and Heavy Sections

Proper design of this product for automatic welding will place the close tolerances near the seam to be welded. If this critical part of the job is held to dimensions, and the chucks or clamps relieved as shown in Fig. 12, then the dimensions of the surfaces not contacted by the chucks will not matter so far as successful welding goes. The line of contact of the chucks with the work is located within narrow limits in this design. Consequently, the work will not only run truer under the arc, but the effectiveness of the clamps in cooling or chilling the plate stock will be uniform.

Tied up closely with clamping and jigging is the backing afforded to the arc weld by the design of the joint. Most applications of automatic metallic arc welding involve single-pass welding, and on high quality jobs, that single pass must be good. Frequently, the use of copper chill bars is called for on work where the porosity resulting from their use would make the weld unacceptable. Instead, backing should be provided by the joint design itself, where possible, either by the use of lap joints, or jogged laps like the one in Fig. 13, in which a seamless tube is joined to a forging.

One special form of backing, often used in atomic hydrogen automatic welding, has special virtues all its own. I refer to the use of hydrogen gas itself as a backing. On stock up to $^1/_8$, or sometimes $^5/_{32}$ in. thickness, the atomic hydrogen arc can be used on butt joints to give 100% fusion through the joint, without sufficient drop-through on the under side to require the use of filler metal to maintain proper joint contour. But if metallic chill bars are used, porosity will usually result from sudden chilling of the molten metal. By relieving the backing strip as shown in Fig. 14, and filling the groove under the joint with hydrogen gas, the hot metal is prevented from reaching the chill bar, and a sound, clean weld results. This gas backing permits the design of products for automatic atomic-hydrogen arc welding where it would be impossible or very costly to use collapsible metal backers, as in welding partly closed cylinders or spheres. In some cases, it is quite common to introduce a jet of hydrogen gas into the container, through a tube which will direct the hydrogen onto the back of the joint immediately under the arc. The hydrogen burns, but before doing so, bathes the underside of the hot metal with hydrogen. This gives extremely effective backing for several reasons.

First, the chilling effect of the gas is gentle, relative to the chilling produced by a copper strip. Second, the chilling effect is uniform, since every part of the metal in the welding zone is contacted by the backing gas. Third, the gas helps support the molten pool by greatly increasing the surface tension of the underside. This is ac-

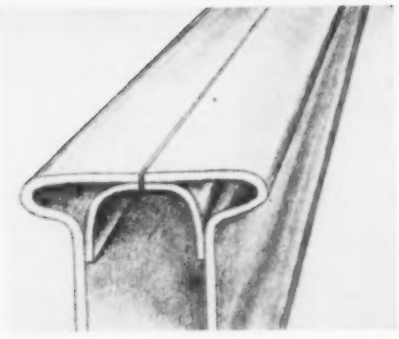


Fig. 16—A Slight Air Space Between Upper and Lower Pairs of Plates to Be Groove-Welded Prevents Uniform Fusion of the Lower Pair in This Design

complished not only by lowering the temperature of the undersurface, but also by preventing the formation of oxides, or reducing those already present. A clean surface has more surface tension than one which is oxidized.

Closely related to clamping, backing, and heat balance is what might be called thermal inertia, or the specific heat of a joint. When welding thick stock, this is not usually of much importance, but in thin stock, so frequently encountered these days, it is something the designer should think about. On light sections, the capacity to absorb heat is small, so that the equilibrium between heat input and outgo becomes quite critical. That is to say, there is little mass or thermal inertia, to soak up and even-out slight variations in the rate of heat input or outflow from the welding zone. Clamping and backing can frequently be used, if the design of the joint is right, to add heat capacity to the joint. In any event, the joint should be designed in such a way as to avoid uneven distribution of heat capacity. In Fig. 15, for example, the left-hand sketch shows poor heat balance between the thin section and the heavy one. Redesigning as shown at the right permits getting the joint away from the heavy thermal sponge that soaks up heat, and makes the welding job much more satisfactory.

Along this same line, conductivity of heat between plates should be given consideration in design. The presence of even a very thin layer of air between two plates will practically insulate them from each other thermally, as far as arc welding goes. This may not be particularly troublesome if an absolutely uniform degree of contact between the plates can be assured, but usually this is not constant, and consequently introduces a very troublesome variable into what should be an absolutely uniform set of conditions.

Figure 16 shows an example of a joint where thermal conductivity trouble was encountered. An attempt was being made to make two butt joints, one over the other, by atomic hydrogen arc welding. Sometimes the fusion was good, and sometimes it was absolutely absent in the joint between the lower plates. In order to use up the stock of previously prepared material, this trouble was overcome by making a thin edge weld on the right-hand pair of plates and on the left-hand pair of plates, before the assembly was put together for welding the butt joint. The thin layer of weld metal on the edges, then, served as a uniform heat transfer means, to afford adequate heat flow into the lower pair of plates.

This joint was redesigned as shown in Fig. 17, to bring all four plates into contact with the heat of the arc, thereby assuring again even flow of heat into the plates, without the preliminary edge weld previously found necessary.

To summarize these ideas, it should be observed that to get the most out of automatic arc welding, the designer must remember that the watchword is uniformity.

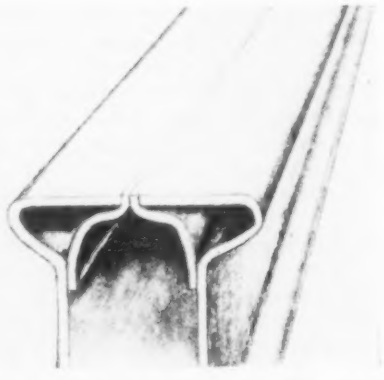


Fig. 17—Redesign of the Part in Fig. 16 Brings All Plates to Be Fused Into Contact with the Arc, and Improves Fusion

This means, in general, uniformity of the radius on work to be rotated under the arc. It means accurately prepared straight seams as well.

The thickness of the stock should be uniform, avoiding welding over lap joints or on tapering sections.

Fit-up must be good—or better than good—to make automatic set-ups pay at all. (On heavy work, a good hand weld at the bottom of the joint is, of course, the equivalent of perfect fit-up.)

Clamping and backing should be carefully thought out before the final design is completed, and provision for their use should be made if needed.

As a final word, let me repeat once more the importance of good fits—the better the fit, the better the job, and in automatic arc welding, the lower the over-all cost.

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(*Continued on page 139*)

Dual Pressure Systems as Applied to Resistance Welding Machines*

By S. M. Humphrey†

THE basic idea of applying other than a single, steady pressure to the electrodes of resistance-welding machines is very old. Over the past thirty years there are many applications on record of the use of a series of pressure variations to accomplish a specific result in resistance welding. Among these applications, one outstanding use is the case of projection welding where a pressure higher than the initial pressure was ultimately placed on the work in order to force the two pieces being welded much closer in contact with one another, thereby improving the over-all characteristics of the projection welded joint.

Another prominent application was in the case of spot welding nonferrous materials, such as brass and aluminum, where dual pressure systems were used primarily to permit obtaining sufficient temperature rise in the spot to cause welding with a minimum of welding current; then immediately after melting, applying a somewhat higher pressure to hold the parts in contact during solidification. This basic idea is described by Norbert Prostler in U. S. Patent No. 1,351,684.

During the past thirty years, The Taylor-Winfield Corp., as well as many of their competitors, have constructed various machines using some form of dual pressure arrangement for one or the other of the above purposes. In all cases, however, the apparatus used could not be considered as of the precision type. While there are no accurate records on hand of the equipment performance, it can be safely said that there was considerable variation in the time and magnitude of the second pressure application. With the vast improvements in other features of welding equipment during the last five years, application of the resistance welding processes to precision work, and with the attendant tightening up of weld quality specifications, it became necessary to develop an accurate and consistent method of applying a dual pressure sequence to resistance welding, if such a sequence were to be used at all in a precision welding machine. Our engineers set about to solve this problem, keeping in mind that the final system must adequately meet the following characteristics:

1. The time of second pressure application in its relation to the welding current must be infinitely adjustable, and must not vary on repeated operation more than ±5% of the specified value.
2. The rate of pressure increase must be as rapid as possible, but at least must increase by threefold in not less than 15 milliseconds.
3. The magnitude of the initial pressure, the slope of pressure increase and magnitude of final pressure must be consistent on repeated operation within ±5% of the specified value.
4. The control equipment and the exhaust valve mechanism must be such that it can run at high speeds, at least 250 per minute, without either electrical or mechanical failure.

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† Executive Engineer, in Charge of Engineering, The Taylor-Winfield Corp., Warren, Ohio.

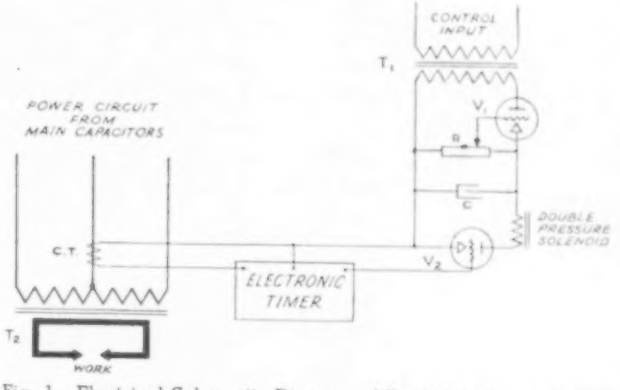


Fig. 1—Electrical Schematic Diagram of Double Pressure System

In analyzing the above specifications, the problem seems to resolve itself into two major components.

First, to develop a solenoid-operated exhaust valve which would permit rapid air exhaust and run at the required speed without mechanical failure.

Second, the design of a timing mechanism, which would be accurate and yet independent of line voltage, frequency, phase relationship, etc., or any mechanical operating conditions of the welder.

Two major methods of timing were considered. One, the method which made use of synchronous timing of the solenoid valve from a given point in the power line supply with simultaneous timing from the same point to the ignition of an ignitron tube, which in case of capacitor discharge welders would be the so-called "series ignitron." This method would accomplish accurate time relation between the pressure and current function, but was discarded because it required some initiation point preceding the start of the welding current, and it would not be applicable to standard a.-c. equipment.

The other method considered, which was the one finally adopted, made use of solenoid valve operated by discharging a capacitor through it. The basic details of this system are shown in Fig. 1. Referring to this figure, the capacitor C is maintained at a uniform voltage by the trickle charging action of the Thyratron tube "V-1," acting as single-phase rectifier. This type of circuit will maintain within ±2% the d.-c. voltage on capacitor C throughout line voltage variations of ±25%, or more. The solenoid which operates the double pressure exhaust valve is placed in series with Thyratron tube "V-2," across capacitor C, in such a manner that as long as "V-2" remains nonconducting, the valve remains closed, but as soon as the grid "V-2" is driven positive with respect to its cathode, the capacitor C will discharge

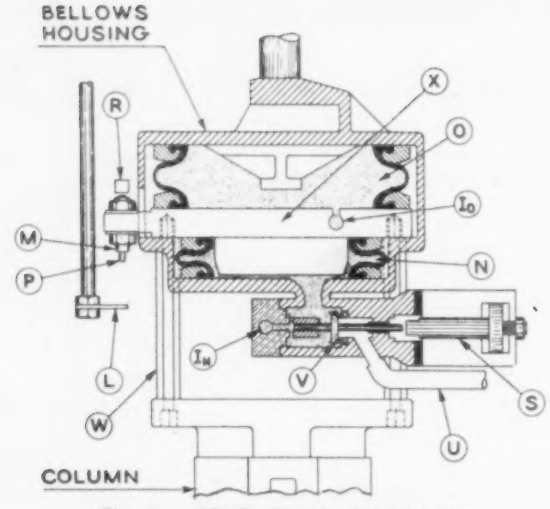


Fig. A - HEAD IN UP POSITION OF OPERATING STROKE

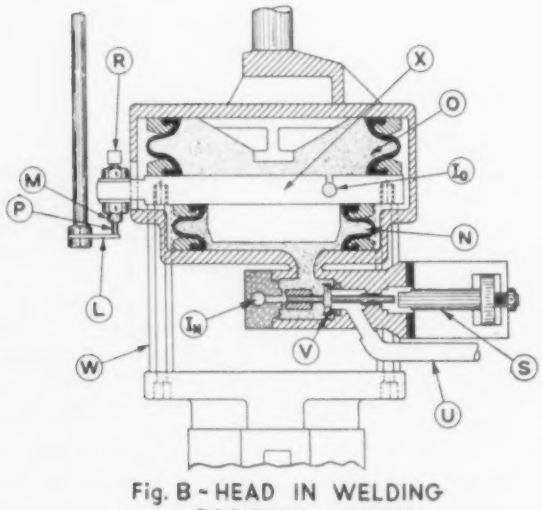


Fig. B - HEAD IN WELDING POSITION, INITIAL WELDING PRESSURE

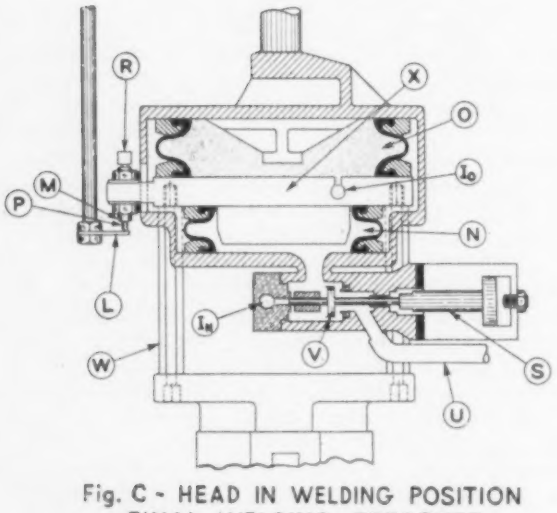


Fig. C - HEAD IN WELDING POSITION FINAL WELDING PRESSURE

Fig. 2—Bellows Double Pressure System Operation Diagram

through tube "V-2," thereby operating the solenoid, which opens the exhaust valve. The mechanism for timing of this discharge with relation to the welding current consists merely of a current transformer placed in series with the primary of the welding transformer, the impulse from which starts off an electronic type of capacitor discharge timing mechanism, which at the end of its preset time interval drives the grid of tube "V-2" positive, thereby operating the exhaust valve, as described above. Accuracy of timing is assured by proper circuit design and use of a regulated source of voltage to feed all timer circuit components. It can readily be seen that such a system is of universal application. The current transformer can be used in conjunction with electrostatic stored energy machines, electromagnetic stored energy machines or standard a.-c. welding machines. In all cases, the initiation of the current through the valve solenoid will be accurately timed from the start of the welding current itself.

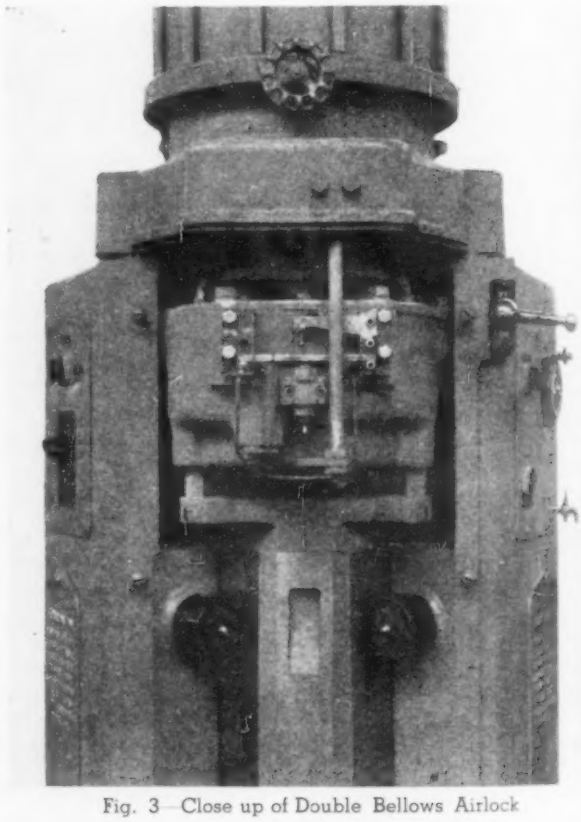


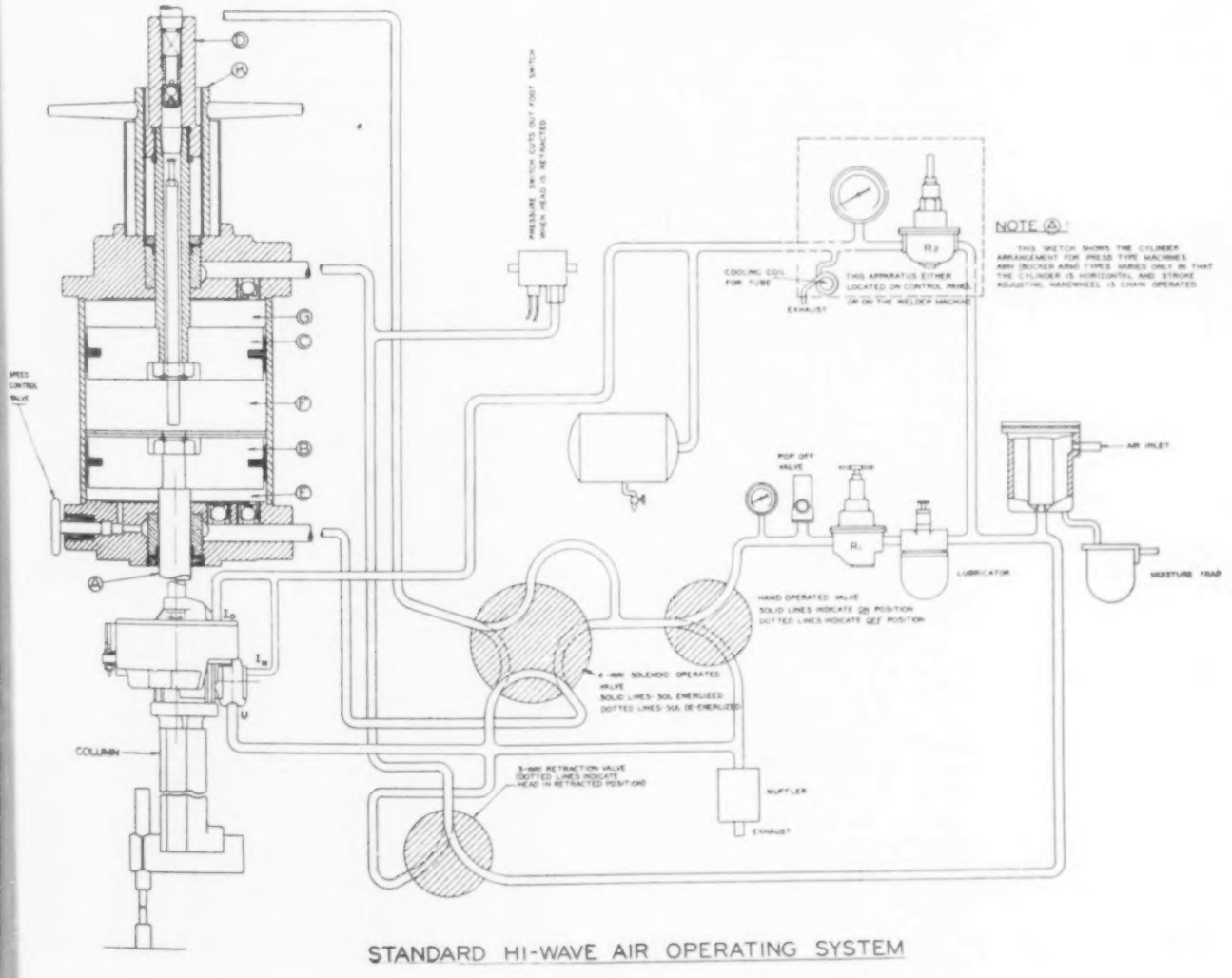
Fig. 3—Close up of Double Bellows Airlock

Fundamentally, the design of a suitable solenoid valve presented a somewhat greater problem. Past experience with solenoid valves operating at high speeds was very disappointing. There was not at the time any solenoid-operated air valves which would run even at 80 spots per minute without undue maintenance, let alone operate at the goal we had set at 250 spots per minute.

Considering basic elements of this problem, it seemed to us that the main reason the solenoid used for operating valves destroyed themselves so rapidly was due to inefficient operation such that only a small portion of the total electrical energy taken from the power supply by the solenoid was used to open the valve. By far the vast proportion of it converted to mechanical energy was dissipated in the solenoid proper, and there were also unnecessary heavy copper and iron losses in the winding and core. It immediately developed that by using the capacitor, we could first accurately control the total

amount of energy delivered to the solenoid. We were then able to construct a solenoid and valve of coordinated design in such a way that the major portion of this energy was used in opening the valve itself. The remaining energy was insufficient to cause excessive impact damage to the solenoid proper. Basically, the final design of the valve consists of a construction in which the solenoid armature in its open position is some distance away from the mechanical member which operates the valve poppet. The constants of the solenoid winding and the capacitor are proportioned so the energy in the capacitor is delivered to the solenoid in extremely short time (approximately 5 milliseconds). This results in a very high force being applied to solenoid armature with attendant high acceleration. The armature then moves forward at a high rate of speed toward the valve stem. At the instant of contact with the valve stem, the kinetic energy in the moving armature is very nearly equal to the original energy stored in the capacitor. Upon striking the valve stem, the valve poppet is forced open against back pressure of the air in the chamber to be exhausted, and in forcing this valve open the major portion of the stored kinetic energy is used up leaving very little to be dissipated in the solenoid armature. Solenoid valves designed on this principle have been successfully operated literally for millions of strokes at 250 strokes per minute with only slight visible signs of mechanical wear, and with only about 30° C. rise in the solenoid winding, a performance which makes it entirely practical to apply such a system to roll spot equipment or other high-speed welding.

The third major problem in developing the over-all equipment for welding machine use was in the air pressure mechanism itself. Here it was desirable to maintain the antifriction features already existing in single-pressure machines, and to obtain a construction which had a minimum volume to be exhausted in order that we could obtain the required rapid exhaust. This result was achieved by using the so-called "double bellows air-lock," which is shown in Fig. 2, and is seen in close-up photograph in Fig. 3, placed in between the main operating cylinder and the column which carries the welding electrodes. Figure 4 shows the over-all pneumatic connections used for operation of the air motor or cylinder which drives the double pressure air lock, as well as connections to the air lock itself. Referring to Fig. 2, Fig. *A* shows the relative position of the upper bellows *O*, the lower bellows *N* and the exhaust valve, when the column is in "up" position corresponding to the welding tips being separated. Note that valve *V* is closed, both bellows are filled with air in such a way that the force exerted by air in bellows *O* is in downward direction on plate *X*, while force exerted by air in bellows *N* on the plate *X* is in upward direction, such that the net force on the plate *X* is difference between the two and this force is applied against the bellows housing shoulder which can be seen at the point where the rod *W* runs into threaded hole in plate *X*. Upon operation of the overhead air



STANDARD HI-WAVE AIR OPERATING SYSTEM

Fig. 4

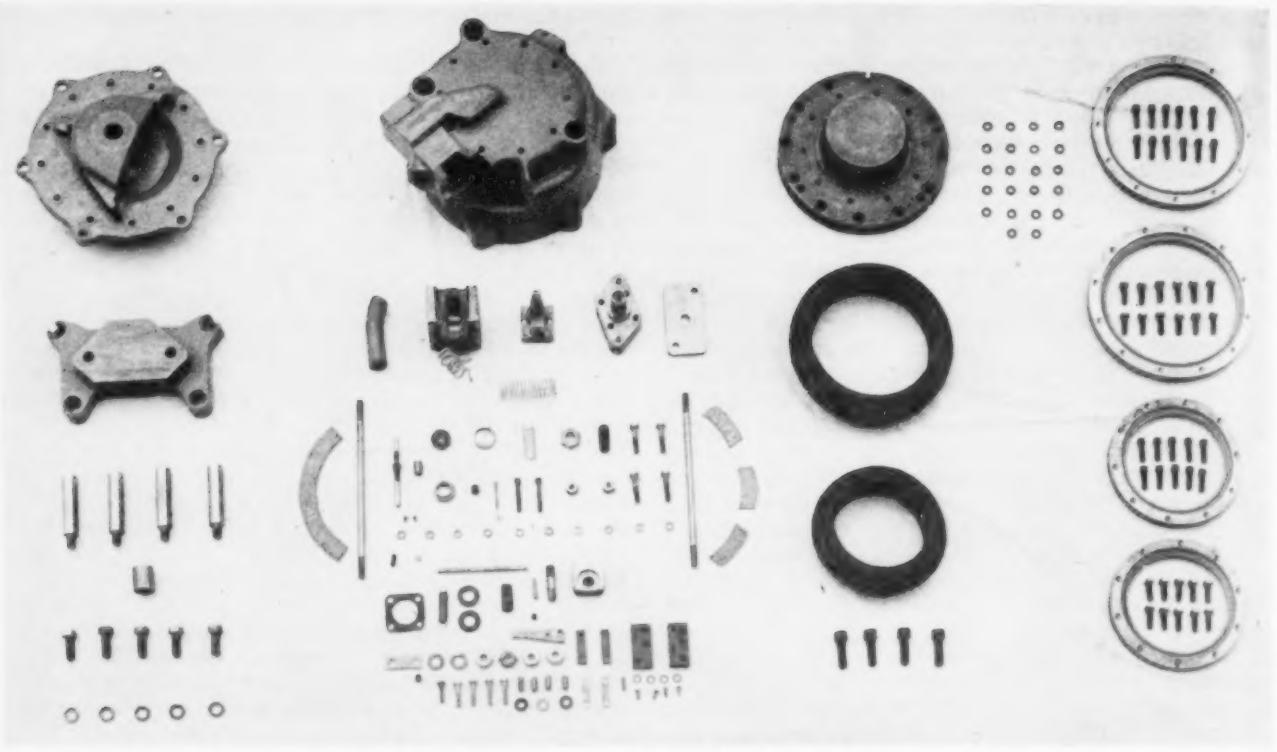


Fig. 5 — Internal Parts of Double Bellows Airlock.

cylinder, the entire unit moves downward with the column until column's downward motion is arrested by tips coming in contact, at which point the plate X ceases its downward motion, since it is rigidly connected to the column through the rods W, but the bellows housing continues on down, resulting in relative position of the parts shown in Fig. B. The only difference is that the net force on plate X has now been transferred from the shoulder of the housing to the column, and hence to the welding tips. At this point, contact is established between the pin P and bar L, also bar R, which initiates the welding current. The welding current, by the process previously described, starts the dual pressure timing mechanism and at the end of its timed period, the exhaust valve is opened resulting in relative position of the parts shown in Fig. C, which differs from Fig. B in that the air in the bellows N has now escaped through valve V, and exhaust tube U, thereby removing the upward force on the plate X, so that the net force on X is now only a downward thrust exerted by air in the bellows O, hence the pressure is increased, thereby obtaining the dual pressure operation. The port I_n is closed to prevent air coming into bellows. In practice, the value of the initial pressure and the second pressure may be controlled by the dimensional design of the pressure unit, and the unit pressure of the air in the bellows. When the head is returned at the end of the welding operation, the valve closes and the bellows N is refilled through the port I_n.

Figure 5 shows the miscellaneous parts which go to make up the dual pressure air-lock unit. Note that main body of the valve is integral part of the bellows housing casting.

Figure 6 shows the dual pressure air-lock assembly in position on testing press for purposes of calibration.

Figure 7 shows over-all view of electrostatic stored-energy machine using this type of duel pressure. The adjustment panel on the right-hand side of the machine carries the selector switch which permits selection of single pressure operation at the second pressure, or dual pressure operation. When using the dual pressure operation, the time interval from the start of the welding current to the start of point of second pressure application is controlled by a potentiometer, and is calibrated directly in milliseconds.

Figure 8 shows an oscillogram of the welding current

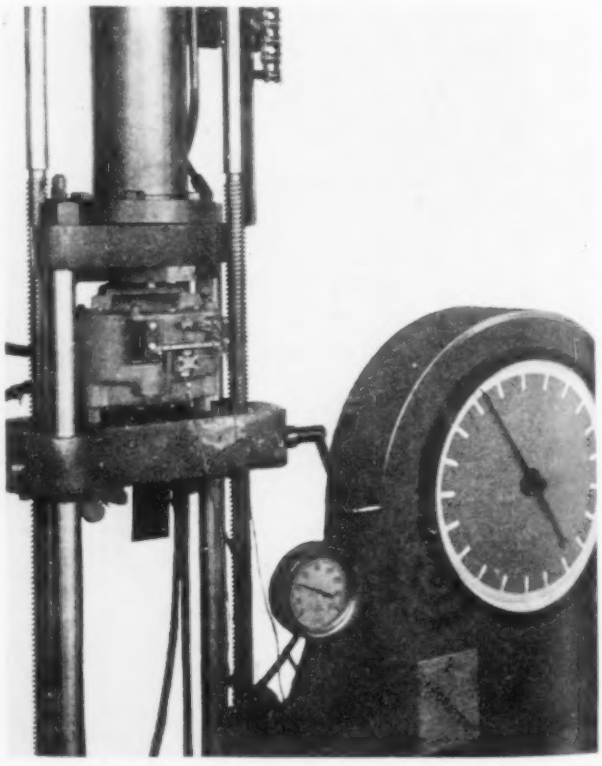


Fig. 6—Air Lock in Testing Press for Calibration

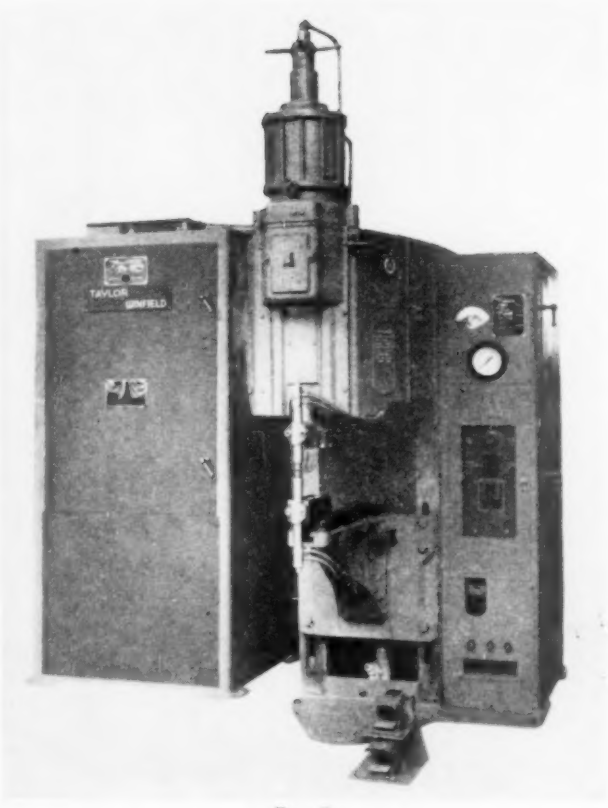


Fig. 7

and the pressure cycle on a capacitor discharge type of welding machine.

From manufacturing point of view, the final adjustment or calibration of this equipment must be made by some sort of adjustment at final inspection on each unit. This can be accomplished by the use of pressure measuring equipment similar to that used to obtain the oscillogram in Fig. 8, but this is a rather clumsy method, involving oscillographic measurement of the time interval elapsing between the first impulse from the current transformer and the application of voltage to the solenoid valve, as now used to set each unit.

There is under development a special type of measuring equipment which will also measure this same interval, but will be rapid and direct reading on instrument without resorting to the use of recording oscillograms on the film. Final measurements of over-all accuracy of the equipment have been very gratifying. An example of the type of accuracy which can be obtained is shown below in results of four different oscillographic films, which took three and four consecutive operations.

Film	Operating Speed, Spots per Min.	Measured Time	Av.	Max. Deviation
1	80	110; 110; 110	110	0
2	80	110; 113; 107	110	±3
3	20	109; 111; 110; 113	110.1	+3
4	20	110; 111; 111; 110	110.5	+1

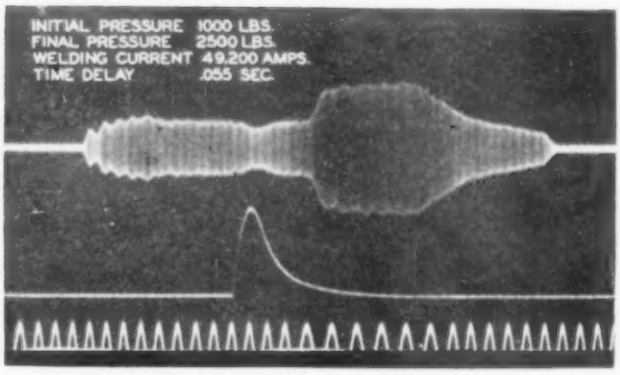


Fig. 8

These particular films demonstrate that there is no difference as function of operating speed. We have also taken similar films before and after long periods of operation and obtained similar results. Deliberate variations of line voltage of ±17% have shown measured changes of ±1½%, respectively.

Everything considered, it is felt that this type of equipment does permit the use of multiple pressure operation on a precision welding machine, and as such we consider it a step forward in the development of such equipment.

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Tentative Weldability Standards for Alternate Aircraft Steels*

By The Aircraft Welding Standards Committee of The American Welding Society

FOREWORD

The tests herein described are presented as satisfactory weldability tests to compare proposed alternate steels with standard aircraft steels. The procedure to be followed by a company or authority when using these tests in determining the acceptability of a proposed steel is not covered. In other words, the composition range, number of heats and lots, the number of independent checks to be included and other matters of procedure are left to be determined for the individual case. After a proposed steel has demonstrated acceptability in these tests it should thus be ready for final tests of acceptability in production.

The standards are based on an investigation conducted by the Subcommittee on Weldability Standards for Alternate Aircraft Steels of the Aircraft Welding Research Committee of the Welding Research Council.

INTRODUCTION

WARTIME necessity has forced the replacement of standard aircraft structural steels by alternate steels, containing smaller amounts of critical alloying elements. Along with this change, the development of testing procedures to ascertain the qualities of the alternate steels became essential.

As many of the new steels would be welded, it became necessary to set up weldability standards for them. The most important aircraft steel for which satisfactory alternates had to be selected was SAE 4130, and most of the weldability tests investigated dealt with steels of this group, i.e., 4130 and its substitutes.

Before extended weldability tests are applied to a proposed alternate steel, standard mechanical and end-quench hardenability tests should be made. These should indicate its equivalence, in the section sizes in question, to the standard steel being compared. Consideration should be given to the spread in hardenability among heats on the high and low side of the composition range and among different heats of similar compositions but affected by different finishing and processing practices, in selecting both the "standard sample" and the particular heats or lots of the new steel to be compared with it. From the standpoint of weldability, the comparison would be more searching when both the selected standard and the new steel have the highest hardenability to be expected within their respective limits of scatter. Comparing a superhardenable example of 4130 with a difficultly hardenable example of a new steel would make the latter appear to an unjustifiable advantage and vice versa.

The weldability tests originally investigated included: (1) Weld Bead Hardness Test, (2) Weld Bead Cracking Test, (3) Longitudinal Butt-Weld Tension Test, (4) Transverse Tension Impact-Test, (5) Tee-Bend Test of $^1/_4$-in. Plate, (6) Transverse Butt-Weld Tension Test of $^1/_4$- and $^1/_8$-in. Flat Stock, (7) Transverse Butt-Weld Tension Test of Tubing and (8) Double-Tube Triangle Test.

After consideration of the data obtained from the several tests, the Committee recommended that Tests 5 to 8 above be used to evaluate the weldability of proposed alternate aircraft steels.

These are "direct comparison" tests upon specimens, welded under the same conditions, from the proposed alternate steel and the standard steel to be replaced. The tests are intended for use in the preliminary qualification, with the number of heats and lots to be tested and other details of procedure left open, to be determined for the specific case. After the preliminary tests described in the following sections have indicated that the alternate steel has an adequate level of weldability, the steel should be subjected to a variety of production tests as the conditions may seem to require. In any case, the alternate steel should be tested by a sufficient number of laboratories, and in a sufficient number of heats and lots, to represent the cross section of material which might be furnished to the industry.

It will be noted that most of the tests herein described are made using the metal arc welding process, and that oxy-acetylene welding is used only in two tests, both on tubing. When the alternate steel is to be fabricated in any great extent by the gas welding process, it is recommended that additional gas-weld tests be made on plate and sheet as well as on tubing, although the double-tube triangle test, with its feature of restraint at the weld joint, should be most useful in testing the gas-weldability of the steel. The assumption, that a steel exhibiting satisfactory weldability when arc-welded will be just as weldable when gas welding is used, is applicable only in tests which are designed to determine the hardening and hard-cracking tendencies of a steel. Steels may be susceptible to hot cracking when oxy-acetylene-welded, although the same steels may be arc-welded without cracking. For this reason it cannot be presupposed that a metal-arc-weld test of a steel will invariably qualify it for oxy-acetylene weldability.

* Proposed Standard. This Standard has not yet been approved. Comments are invited. To be considered these comments should be addressed to the Chairman, Aircraft Welding Standards Committee, AMERICAN WELDING SOCIETY, 33 West 39th St., New York 18, N. Y., and should arrive not later than March 10, 1944.

TEE-BEND TEST

Testing Procedure

* Proposed Standard. This Standard has not yet been approved. Comments are invited. To be considered these comments should be addressed to the Chairman, Aircraft Welding Standards Committee, American Welding Society, 33 West 39th St., New York 18, N. Y., and should arrive not later than March 10, 1944.

TEE-BEND TEST

Preparation of Specimen

Material.—1/4-in. plate.

Joint.—Double-fillet tee, 3/16-in. fillets. Details in Fig. 1.

Electrode.—1/8-in. plain-carbon steel, covered (AWS-ASTM Class E 6013).

Preheat.—Welding at 80° F. ± 10° F., initial and interpass; tacking at 200° F.

Welding Procedure.—The two pieces forming the joint are tack welded together at both ends of the joint. The joint is then clamped into a jig such that welding may be done in the flat position, the region of the joint being insulated from the jig by asbestos sheet. Each fillet weld is made in one pass approximately 6 in. long. Both fillets should start at the same end of the joint and progress at the same welding speed.

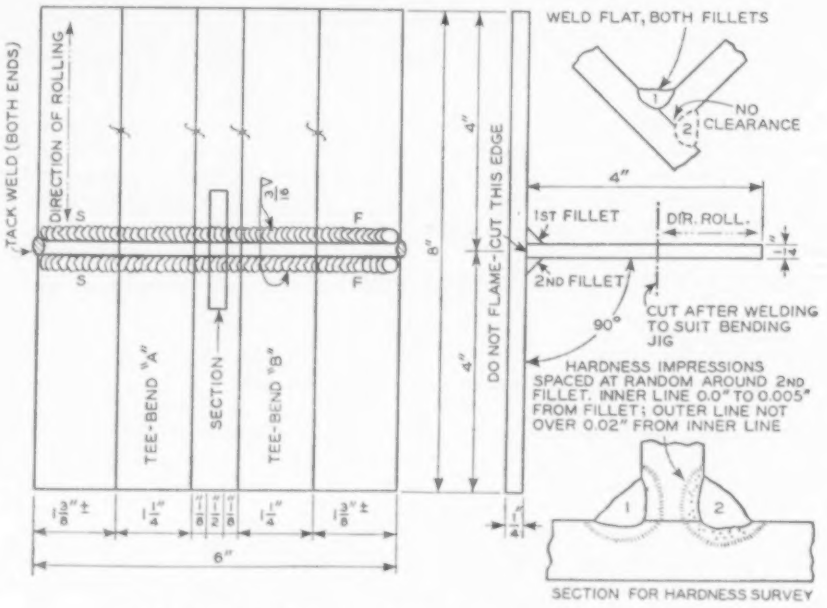


Fig. 1—Weld Specimen for 1/4-In. Plate Tee-Bend Test

Test Specimens.—Each joint is machined into two bend specimens and one section for microscopic and macroscopic examination as indicated in Fig. 1. Tension edges of the bend specimens are rounded off with a fine file. The section is polished through a No. 600 abrasive, then lightly etched to develop the microstructure.

Testing Procedure

Two welded joints are made from the proposed alternate steel and two from the control.

Tee-Bend Specimens.—All four specimens of each steel are tested in the as-welded condition. They are placed in a standard tee-bend jig (for details refer to page 137-s, Welding Research Supplement, The Welding Journal, March 1942, and page 485-s, Welding Research Supplement, The Welding Journal, October 1942) and loaded slowly to the limit of the jig or until complete failure occurs. Records are made of load and angle of bend at the appearance of the first crack, and again at maximum load.

Location and type of fracture are also recorded for each specimen. The common types of fracture found in aircraft steels are illustrated in Fig. 2.

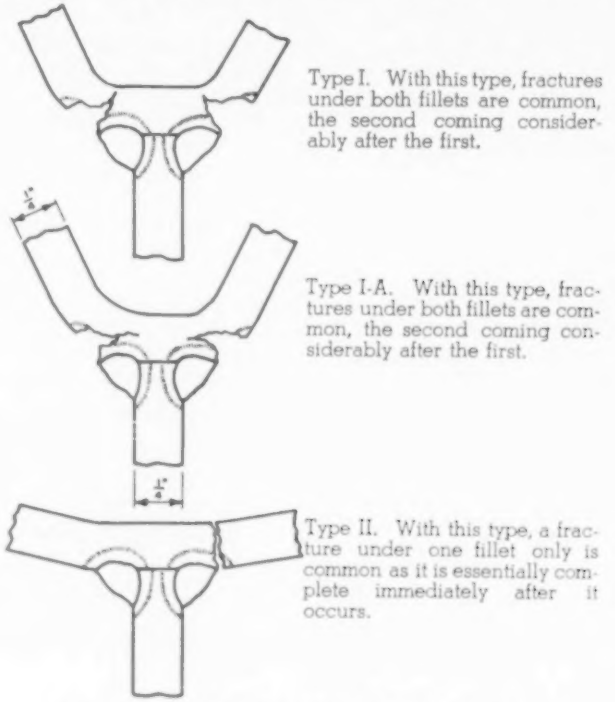

Type I. With this type, fractures under both fillets are common, the second coming considerably after the first.
Type I-A. With this type, fractures under both fillets are common, the second coming considerably after the first.
Type II. With this type, a fracture under one fillet only is common as it is essentially complete immediately after it occurs.

Fig. 2—Types of Fractures in Tee-Bend Specimens

They may be described as follows:

Type I: Fracture starts at the toe of the fillet weld, progresses rapidly along the boundary of the heat-affected zone and then across the plate section at a slower rate. The fracture generally appears silky in the heat-affected region and fibrous elsewhere. When two cracks occur, the second

generally comes considerably after the first, starting at the root of the opposite fillet. The specimen bends to the full capacity of the jig without complete fracture.

Type I-A: This is substantially the same as Type I, except that the fracture, after starting at the toe of the fillet and curving around the heat-affected zone, progresses inward along the plane of the plate, under the fillet weld, approximately at mid-section. This type of fracture (or no fracture, a condition rarely found with aircraft steels) constitutes acceptable weldability according to Navy Department standards based on previous tests on a variety of steels. In the tests of aircraft structural steels, however, there are only slight differences between the Type I and Type I-A fractures, and both are considered as indicating satisfactory weldability.

Type II: Fracture starts at the toe of the fillet weld and progresses rapidly in a direct line to the opposite surface of the plate. This type of fracture is usually quite audible, and is essentially complete immediately after the maximum load has been reached. The fracture is sharp and brittle. (Another type of fracture seldom found in aircraft steels is what might be called the Type II-A fracture in which complete fracture occurs, but in which the progress of the fracture more nearly resembles that of Type I.)

Type I and I-A fractures indicate a higher level of weldability than Type II.

Sections.—Sections are first examined under the microscope for cracks in the parent metal adjacent to the weld. The maximum hardness in the heat-affected parent metal and average hardness of the unaffected parent metal are then obtained. For hardness surveys a hardness testing machine capable of making small closely spaced impressions is essential. A suggested hardness survey pattern is indicated in Fig. 1.

Test Results

Tee-Bend Specimens.—In order to qualify for use in place of a standard steel, specimens of a proposed alternate steel should have the same or a better type of fracture. They should also be able to withstand equal or greater bending loads, at the same time showing angles of bend not less than the corresponding angles of bend found with specimens of the standard steel.

Sections.—Cracks in the heat-affected parent metal adjacent to the weld are definite indications of poor weldability. To qualify as a replacement for a standard steel, a proposed alternate steel should generally show no cracks in the parent metal; but in any case the extent of cracking should not be more than that found in the standard steel, and the preheat necessary to eliminate cracking should be as low as a similar preheat for the standard steel.

Tests have shown that the correlation between weldability and maximum hardness in the heat-affected parent metal, adjacent to the weld, is not exact. However, excessively high hardness maxima generally indicate a low level of weldability. While it is conceivable that a new steel might prove satisfactory at a higher hardness level than the standard, exhaustive tests would be needed to prove it. Hence, as a first approximation, an acceptable alternate steel should not develop a maximum hardness in the heat-affected zone adjacent to the weld appreciably greater than that developed in the corresponding zone of a standard steel. Weldability tests have shown that steels developing hardness maxima in this heat-affected zone, which are in excess of 550 V.H.N. may be expected to have a very low level of weldability. In general, hardness maxima should not greatly exceed 500 V.H.N.

TRANSVERSE BUTT-WELD TENSION TEST TEST OF 1/4 -IN PLATE

Preparation of Specimen

Material.—1/4-in. plate.

Joint.—Double-vee butt or single-vee butt with backing strip (see Testing Procedure). Details are given in Figs. 3 (*a*) and 3 (*b*). Do not flame scarf.

Electrode.—5/32-in. alloy steel, aircraft type, covered (usually a mixed cellulose and mineral coating containing some alloying elements).

Preheat.—Welding: 80° F., initial and interpass.

Welding Procedure.—Pieces to be welded are aligned in a jig without prior tack welding, the region of the joint being insulated from the jig with asbestos sheet. The joint is welded in two continuous passes, each approximately 6 in. long. Both passes should start at the same end. The double-vee joint is preferable, but frequently, with higher alloy or higher carbon steels, cracks in the base metal adjacent to the weld have been found after the first pass, apparently starting in the root of the joint at the sharp angle between the protruding weld metal and the beveled plates. While such cracking in itself gives a measure of the weldability of the steel under test, tensile properties of the joint cannot be measured. The single-vee joint is then used.

Test Specimens.—Each welded plate is machined into two tension specimens and one section for microscopic and macroscopic examination, having the dimensions indicated in Fig. 3 (*a*). Weld reinforcements and backing strip may be removed, but, in general, this is not necessary, because the object of the test is to determine the tensile properties of the heat-affected base metal, and not of the weld metal. In the case of the single-vee joint, however, it is advisable to machine the backing strip to within approximately 1/32-in. of the plate surface, so that it will not affect the tensile strength.

Testing Procedure

Three plates of the proposed alternate steel and three of the standard are welded. The two tension specimens from one of these plates are left as-welded, the two from the second plate are normalized and the two from the third plate are quenched and drawn to an ultimate tensile strength of 150,000 psi in the plate. Excessive scaling and decarburization of the specimens during heat treating should be prevented.

All tension specimens are grit blasted, then marked off into 1/4-in. incre-

ments over the 4-in. reduced section. They are then pulled in tension at a slow rate of loading (5000–10,000 lb./min.). During loading the yield

a low level of weldability. While it is conceivable that a new steel might prove satisfactory at a higher hardness level than the standard, exhaustive

ments over the 4-in. reduced section. They are then pulled in tension at a slow rate of loading (5000–10,000 lb./min.). During loading the yield strength and ultimate tensile strength are obtained, and the elongation measured on a 2-in. gage length spanning the fracture. Location and type of fracture are also recorded.

Measurements of yield strengths and elongation of transverse butt-weld tension specimens are not numerically exact, especially where the tensile properties of the weld metal and base metal differ considerably, and where the weld reinforcement is not removed, but they offer a fair indication of the mechanical properties of the weld joints, and are, therefore, suitable for comparison of two joints welded in the same manner.

Section—Sections are not heat treated and ordinarily only one of the three from each steel is studied. These are polished through a No. 600 abrasive, etched lightly to develop the microstructure and examined under a microscope for cracks in the heat-affected base metal adjacent to the weld. Following this, they are surveyed for maximum hardness in the heat-affected parent metal and average hardnesses of the weld metal and unaffected parent metal. For these hardness surveys a hardness testing machine capable of making closely spaced impressions is essential. A suggested survey pattern is indicated in Fig. 3 (*b*).

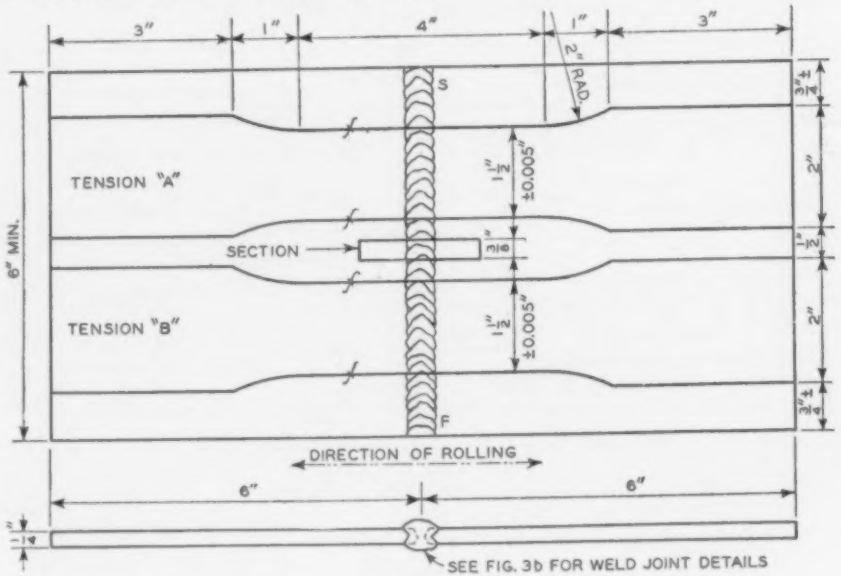


Fig. 3 (*a*)—Weld Specimen for ¼-In. Plate Transverse Tension Test

Test Results

Tension Specimens.—For an alternate steel to be qualified to replace a standard steel, such as SAE 4130, butt-weld tension specimens of the alternate steel should show equally high ultimate tensile strengths, yield

mens during heat treating should be prevented.

All tension specimens are grit blasted, then marked off into ¼-in. incre-

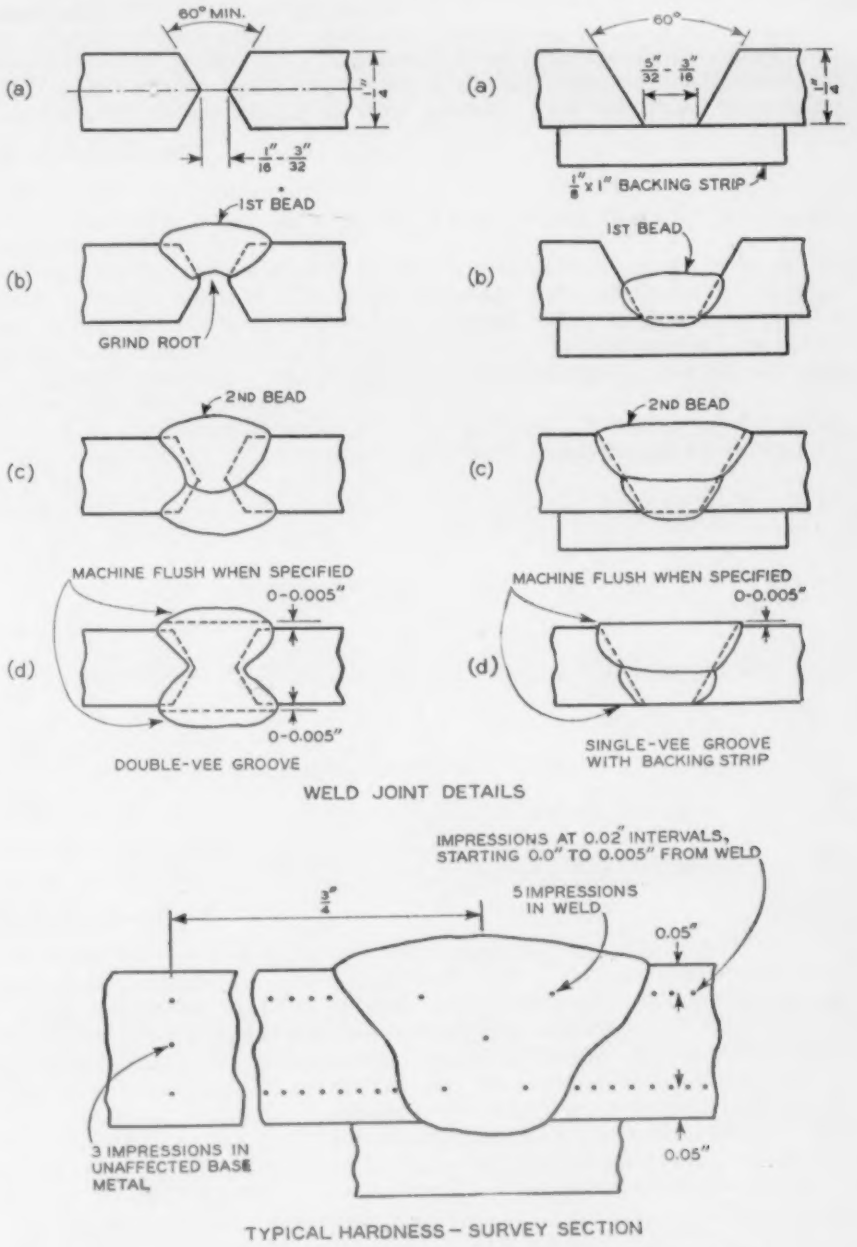


Fig. 3 (*b*)—Details of Weld Joints for ¼-In. Plate Transverse Tension Test

strengths and elongations, as well as equally satisfactory types of fractures.

Sections.—Refer to the discussion of microscopic examinations and hardness surveys given in the section on tee-bend tests (page 142).

TRANSVERSE BUTT-WELD TENSION TEST OF 1/8-IN. SHEET

Preparation of Specimen

Material.—1/8-in. sheet.

Joint.—Single-vee closed butt. Details are given in Fig. 4. Do not flame scarf.

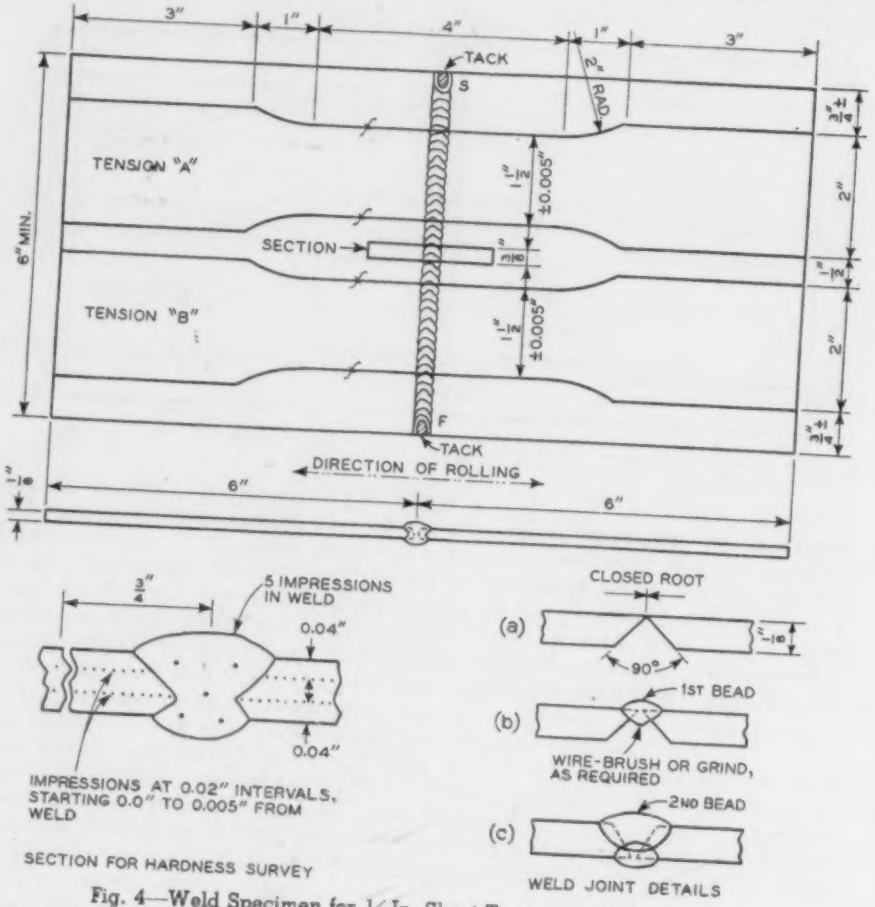


Fig. 4—Weld Specimen for 1/8 In. Sheet Transverse Tension Test

Electrodes.—3/32- and 1/8-in. plain-carbon steel, covered (AWS-ASTM Class E 6013).

Preheat.—Welding at 80° F. ± 10° F., initial and interpass; tacking at 200° F.

Welding Procedure.—Pieces to be welded are tacked at both ends of the joint. The tacked plate is then clamped in a jig to maintain the alignment of the joint edges, the region around the joint being insulated from the jig with asbestos sheet. The joint is welded in two continuous passes, each approximately 6 in. long. The first is made with a 3/32-in. electrode on the side away from the opening of the vee, penetrating through the root of the vee to give a sound backing for the second pass. The second pass is then made from the opposite side with a 1/8-in. electrode.

Test Specimens.—Tension specimens are machined according to the dimensions indicated in Fig. 4. As with the 1/4-in. specimens, the weld reinforcements may be removed, but they usually are not.

Testing Procedure

The same testing procedure is used as for the 1/4-in. specimens. A suggested hardness survey pattern is indicated in Fig. 4.

Test Results

Refer to discussion of test results in the section on the transverse butt-weld tension test of 1/4-in. plate.

TRANSVERSE BUTT-WELD TENSION TEST OF 1-IN. TUBING

Preparation of the Specimen

Material.—1-in. x 0.065-in. and 1-in. x 0.049-in. seamless or seam-welded tubing.

Joint.—Square closed butt. Details in Fig. 5.

Electrode.—3/32-in. plain-carbon steel, covered (AWS-ASTM Class E 6013).

Gas-Welding Rod.—1/16-in. low-carbon steel (AWS-ASTM Class GB45).

Preheat.—Arc welding at 80° F. ± 10° F.; tacking at 200° F., gas welding and tacking as required.

Welding Procedure.—Two lengths of tubing are aligned in a jig and their squared ends butted together and tack welded. During welding the specimen is held in a horizontal plane and manually rolled, so that all welding is done in the flat position. Arc welds are made in two increments each half-way around the circumference, while oxy-acetylene welds are made in one continuous pass.

Test Specimens.—The 14-in. length of butt-welded tubing constitutes the test specimen. Other than cleaning, no further preparation is required.

Testing Procedure

Six specimens are welded by each method. One set of two arc-welded and two gas-welded specimens are left as-welded, a second set is normalized and a third set is quenched and drawn to an ultimate tensile strength of 150,000 psi, for the tubing. Excessive scaling and decarburization during heat treatment should be prevented.

The specimens are tested for tensile strength according to the Standard

Class E 6013).

heat treatment should be prevented.

The specimens are tested for tensile strength according to the Standard Methods of Mechanical Testing of Welds adopted by the AMERICAN WELDING SOCIETY. In addition to the ultimate tensile strengths, the locations and types of fracture are also recorded.

Owing to the character of the welded joint, measurements of the yield strength and elongation are not significant, and are, therefore, omitted.

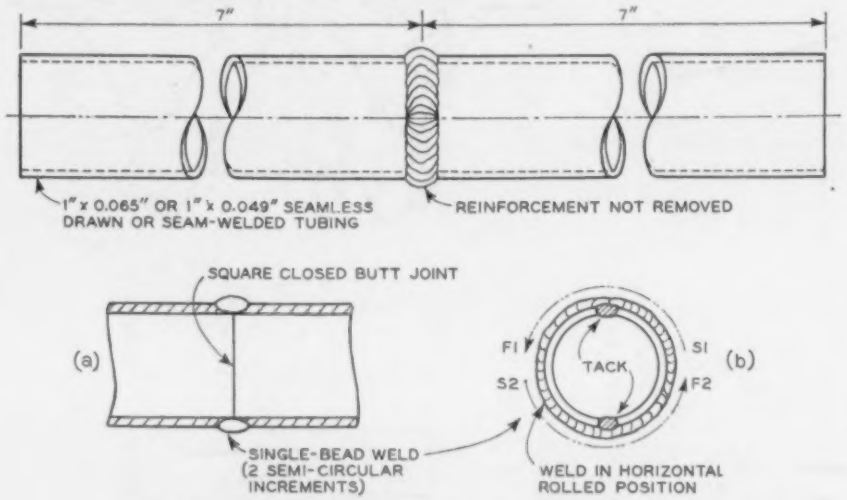


Fig. 5—Specimen for Butt-Welding Tubing Tension Test

Test Results

For an alternate steel to be qualified to replace a standard steel such as SAE 4130, butt-welded tension specimens of the alternate steel should show equally high ultimate tensile strengths, as well as equally satisfactory types of fractures. It should also show no greater tendency to crack adjacent to the weld at any preheat temperature.

WELDED DOUBLE-TUBE TRIANGLE TEST

While the tests already discussed have been previously employed in a variety of investigations, the Committee developed the double-tube triangle specimen especially for aircraft applications, because it presents miter, cluster and gusset joints similar to those found in tubular aircraft structures, and also sets up stresses in the assembly similar to those which might be present in a tubular aircraft structure.

Preparation of the Specimen

Material.—1-in. x 0.065-in. and 1-in. x 0.049-in. tubing; 0.049-in. sheet.

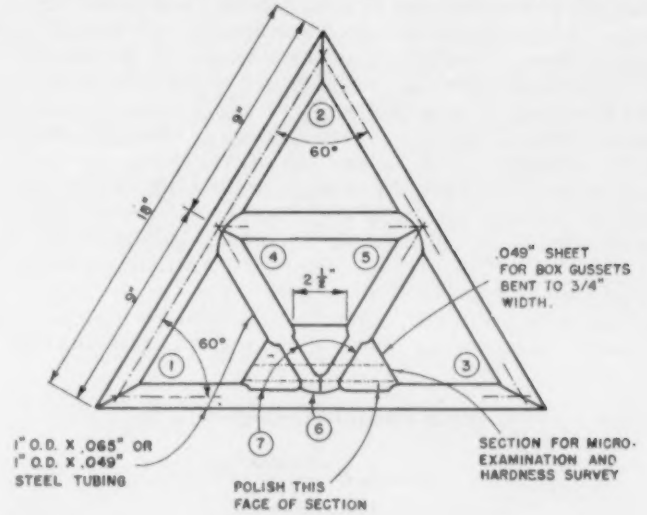
Joints.—Miter, cluster and gusset. Details in Figs. 6 (*a*) and 6 (*b*).

Electrode.—$^3/_{32}$-in. plain-carbon steel, covered (AWS-ASTM Class E 6013).

Gas-Welding Rod.—$^1/_{16}$-in. low-carbon steel (AWS-ASTM Class GB45).

Preheat.—Arc welding at 80° F and −40° F.,* initial and interpass; gas welding at 80° F., initial. Tacking: arc-welded specimens at 200° F.; gas-welded specimens as required.

Welding Procedure.—Lengths of tubing are properly shaped, then fitted in a jig and tacked to form a double triangle as shown in Fig. 6 (*a*). The joints are then welded in the order indicated in this figure. Three gussets are fitted around the final cluster joint (No. 6), and welded as shown. The sequence of welding of the individual joints and the gussets is shown in


9"
9"
18"
60°
60°
2½"
.049" SHEET FOR BOX GUSSETS BENT TO 3/4" WIDTH.
1" O.D. X .065" OR 1" O.D. X .049" STEEL TUBING
POLISH THIS FACE OF SECTION
SECTION FOR MICRO-EXAMINATION AND HARDNESS SURVEY
JOINTS WELDED IN ORDER INDICATED WITH TRIANGLE IN FLAT POSITION. USING 3/32" CLASS E6013 ELECTRODES OR 1/16" CLASS GB 45 WELDING WIRE. INITIAL AND INTERPASS TEMP. FOR ARC-WELDED TRIANGLES 80° OR −40°F. GAS-WELDED TRIANGLES WELDED WITHOUT PAUSE.

Joints welded in order indicated; for detail welding sequence see Fig. 6 (*b*).

Fig. 6 (*a*)—Double Tube Triangle for Restrained-Weld Test

Fig. 6 (*b*). Prior to welding, $^1/_8$-in. holes are drilled in the tubular members, being so located that the entire assembly may be tested under air pressure.

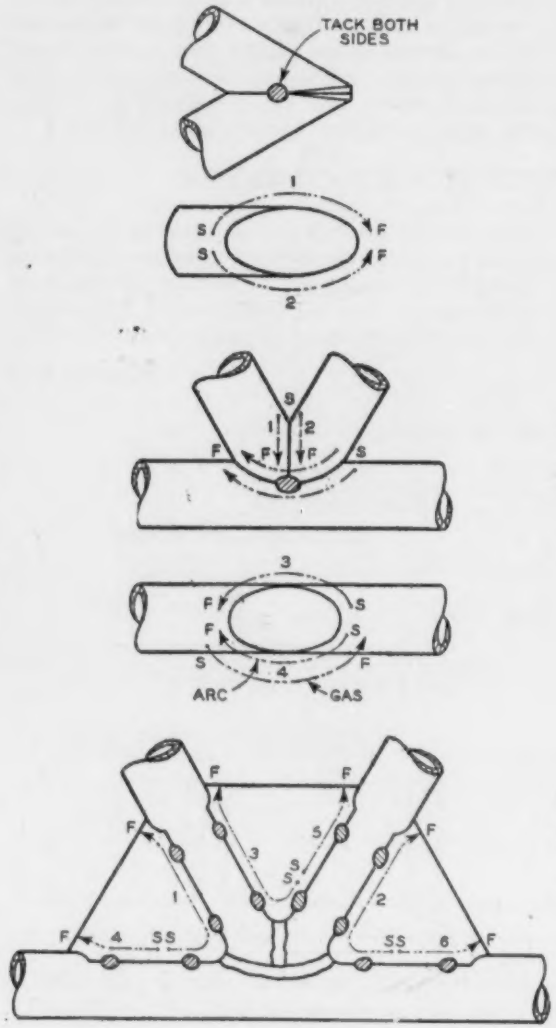
Metal-arc-welded specimens are made using 1-in. x 0.065-in. tubing, and gas-welded ones using 1-in. x 0.049-in. tubing. The gusset plates are 0.049-in. thick for both arc- and gas-welded specimens.

Test Specimen.—The entire welded double-tube triangle assembly constitutes the test specimen.

* Welding at −40° F. is used only with this test, because the other tests are not sufficiently critical to distinguish between the effects of welding at −40° F. and at 80° F.

Testing Procedure

Two triangles are welded at 80° F., two are welded at −40° F. and two gas welded at 80° F. are made from both the proposed alternate steel and the standard steel (six specimens for each steel).



Welding Sequence for Joints (1), (2), (3)

a. Weld increment "1"
b. Turn over, weld increment "2"

Welding Sequence for Joints (4), (5), (6)

a. Weld increment "1"
b. Turn over, weld increment "2"
c. Weld increment "3"
d. Turn over, weld increment "4" } arc welding
c. Weld increment "3"
d. Turn over, weld increment "4", start at end of increment "3" } gas welding

Welding Sequence for Gussets, Joint (7)

a. Weld "1", "2", "3", "4", "5" and "6"
b. Turn over, start opposite S for increment "2", and repeat sequence

All welding done with triangle in horizontal plane

Fig. 6 (*b*)—Detail Welding Sequence for Joints of Double Tube Triangle

After the welds are wire-brushed and the triangles lightly grit-blasted, each triangle is pressure tested to detect leaks. The joints are coated with a soap solution, and air at about 100 psi. pressure is forced into the assembly. Location and extent of all leaks are recorded.

The triangles are next subjected to magnetic particle inspection (continuous d.-c. wet method) of all welded joints. Location and extent of all cracks are recorded.

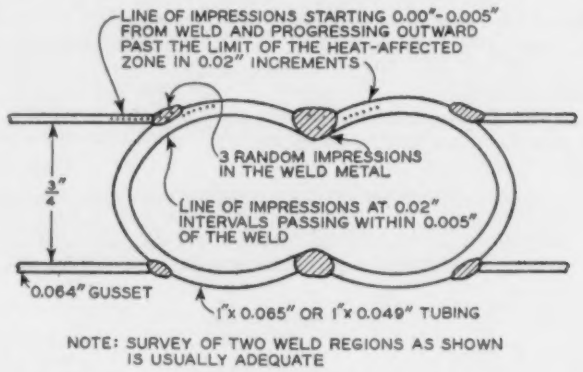

LINE OF IMPRESSIONS STARTING 0.00"-0.005" FROM WELD AND PROGRESSING OUTWARD PAST THE LIMIT OF THE HEAT-AFFECTED ZONE IN 0.02" INCREMENTS
3 RANDOM IMPRESSIONS IN THE WELD METAL
3/4"
LINE OF IMPRESSIONS AT 0.02" INTERVALS PASSING WITHIN 0.005" OF THE WELD
0.064" GUSSET
1"x 0.065" OR 1"x 0.049" TUBING
NOTE: SURVEY OF TWO WELD REGIONS AS SHOWN IS USUALLY ADEQUATE

Fig. 6 (*c*)—Section for Hardness Survey

After the magnetic particle inspection, sections are taken from the gusset joints of each triangle, immediately above the continuing member as indicated in Fig. 6 (*a*). Each section is polished and lightly etched to develop the microstructure.

Sections are examined under the microscope for cracks in the heat-affected parent metal. Following this, hardness surveys are made to determine: (1) the maximum hardness in the tubing adjacent to the weld, (2) the maximum hardness in the gusset sheet adjacent to the weld, (3) the average hardness of the weld metal, (4) the average hardness of the unaffected tubing and (5) the average hardness of the unaffected gusset sheet. For these surveys a hardness testing machine capable of making small closely spaced impressions is essential. Owing to the thinness of the tubing and gussets, the hardness surveys are difficult to make, and exact spacing of the impressions must be left to the operator of the machine. A possible hardness survey pattern is suggested in Fig. 6 (*c*).

Test Results

In order for an alternate steel to be qualified to replace a standard steel, the triangular specimens made from it should show no more extensive leaks or cracks than specimens made from the standard steel.

The same considerations that apply to data from tests on tee-bend macrosections (page 142) apply also to the data obtained from tests on the gusset sections of the double-tube triangles.

A NEW RESOURCE HAS BEEN DEVELOPED

THE WEALTH of America has been wrought from her natural resources of fertile lands, wide forests and rich mineral deposits by the brains and muscles of her people.

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Research means imagining and experimenting. It means the searching out and bringing together of facts. It means clear statements of problems, precise measurements and keen analysis. It means tenacious following along unexpected paths.

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BELL TELEPHONE SYSTEM

Helium-Shielded Arc Welding of Magnesium Alloys*

By F. A. Wassell†

ONE of the most important factors contributing to the greatly expanding use of magnesium alloys in industry is helium-shielded arc welding. This process eliminates the use of fluxes and permits the welding of practically all of the commercial alloys. It also presents a very flexible means of fabricating these light-weight, high-strength alloys.

This paper is the result of an investigation of the welding of light gages of magnesium alloys, and was written for the purpose of acquainting other investigators and users of the process with specific problems uncovered and some of the possible solutions of these problems.

Welding Power

The heldium-shielded arc welding of magnesium alloys is a direct-current process utilizing standard types of direct-current welding machines. For the welding of the lighter gages of magnesium, up to around $^3/_{16}$ in., small welders of approximately 150 amp. capacity are used; but for the welding of the heavier gages or for high-speed welding, machines of about 300 amp. are required.

Magnesium is always welded with reverse polarity, that is, with the electrode positive and the work negative. Straight polarity results in an unstable arc and excessive spatter.

Helium

Commercial helium of 98% purity, as supplied by various gas companies, is sufficiently pure to give satisfactory welding results. Excesses of impurities, such as water, hydrogen and nitrogen, have very pronounced undesirable effects on the welds. Water will break down in the arc to form oxygen and hydrogen; the oxygen reacts to form magnesium oxide while the hydrogen, being very readily absorbed by the molten metal, produces bad porosity. Nitrogen reduces the welding speed considerably.

* Adapted from a talk presented at the Annual Meeting of the American Society for Metals.

† Welding Engineering Div., General Electric Co.

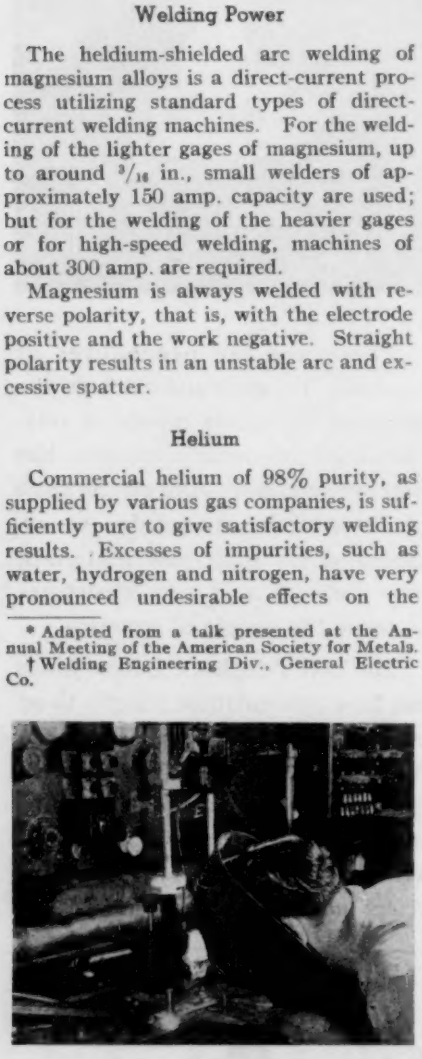


Fig. 1—Magnesium Plate Being Welded at G-E Welding Laboratory. Shows Major Part of Equipment

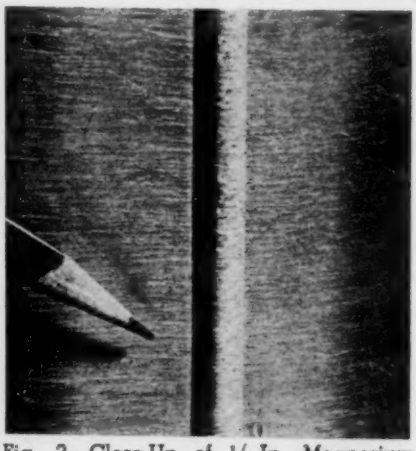


Fig. 2—Close-Up of $^1/_8$-In. Magnesium Plate; Automatically Welded with G-E Helium-Shielded Arc-Welding Equipment at 24 In. per Minute

Mechanics of Welding

Helium-shielded arc welding may be likened to carbon arc welding in that the arc is maintained between an electrode and the work, and any required filler metal is fed into the arc from an outside source. The apparatus used consists essentially of a tungsten electrode and a gas nozzle or cup which surrounds the electrode. Helium is fed to the nozzle in such a way that it flows down around the electrode and out the lower end of the nozzle to completely envelope the lower end of the electrode and the work directly beneath it. The arc, struck in this envelope of helium by touching the electrode to the work and quickly drawing it back a short distance, is maintained at the starting point for a period of time sufficient to establish a molten pool on the work. The end of the filler rod is then advanced to the arc which rapidly melts it down so that the filler metal flows into the molten pool. When sufficient filler metal has been deposited, the rod and the arc are advanced to a point where more filler metal can be added to the molten pool. The welding progresses in this manner to form a continuous bead. In machine welding, the filler metal is fed into the arc at a uniform rate, depending on the welding speed, and produces a very uniform bead contour with barely perceptible ripples. Manual welding produces a less uniform bead contour for the reason that the filler metal cannot be fed as evenly into the arc by hand.

Figure 1 shows an automatic helium-shielded arc welding equipment in operation. Figure 2 shows a close-up view of the welding of magnesium plate, and Fig. 3, a butt joint on $^1/_8$-in. magnesium plate, automatically welded. Figure 4 shows a manual helium-shielded arc-welding electrode holder. This holder is shown in Fig. 5, being used to weld two magnesium plates together.

For best results, the filler rod should be held at an angle to the work of not more than 30° and preferably as near to 0° as possible. When it is held at too steep an angle, the rod becomes very hot due to heat radiated from the arc and tends to melt off outside the area of the molten pool. This causes arc instability and results in a bead of uneven appearance and poor fusion.

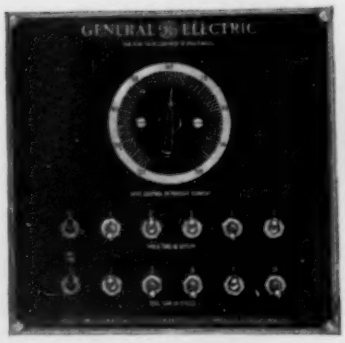
The electrode should be held as nearly perpendicular to the work as possible in order to direct the flow of helium so as to maintain the proper coverage of both the arc and the work. In hand welding, the electrode is usually inclined somewhat away from the vertical so that the operator may have a good view of the arc and of the weld pool. This angle of deviation from the vertical, however, should not exceed 30°. In machine welding, the vertical position is maintained very easily.

Fig. 3—Close-Up View of Welding Operation. Shows Helium Shield

Joint Preparation

Any of the standard types of joints, and modifications of them, can be used in this process. Some of the joints most commonly used are butt joints of the square-groove, single V-, double V- and U-types. Others that can be used are fillet, corner, edge, flange and lap joints.

New Electronic Control for Seam Welding



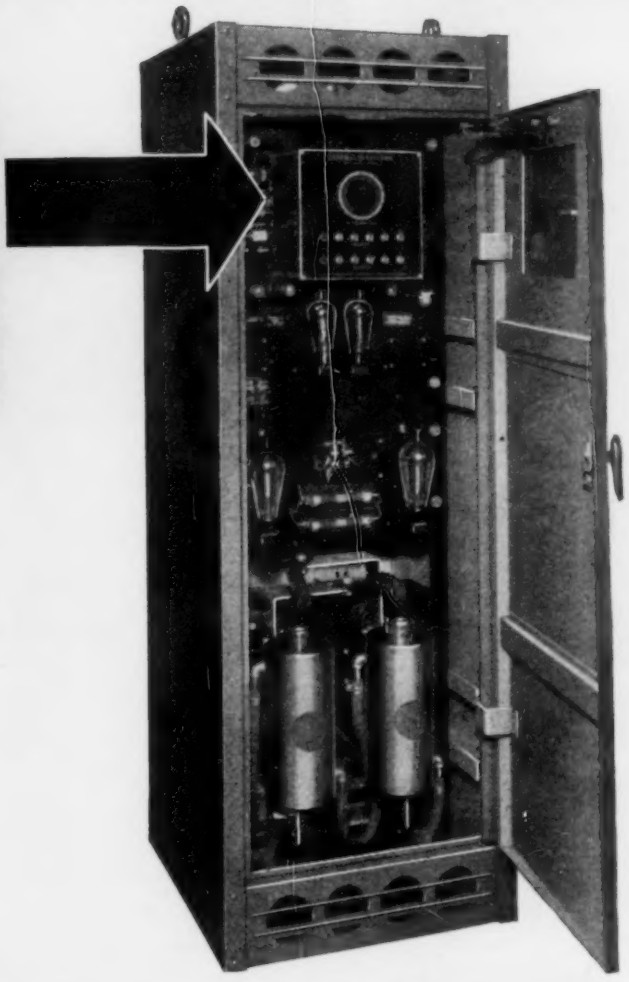


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Fig. 4—G-E Helium-Shielded Arc-Welding Electrode Holder for Manual Welding. Helium Gas Flows Around Tungsten Electrode Which Can Be Seen Protruding from End of Holder

Fig. 5—Manual Helium-Shielded Arc Welding Being Done on Light-Gage Magnesium Plate

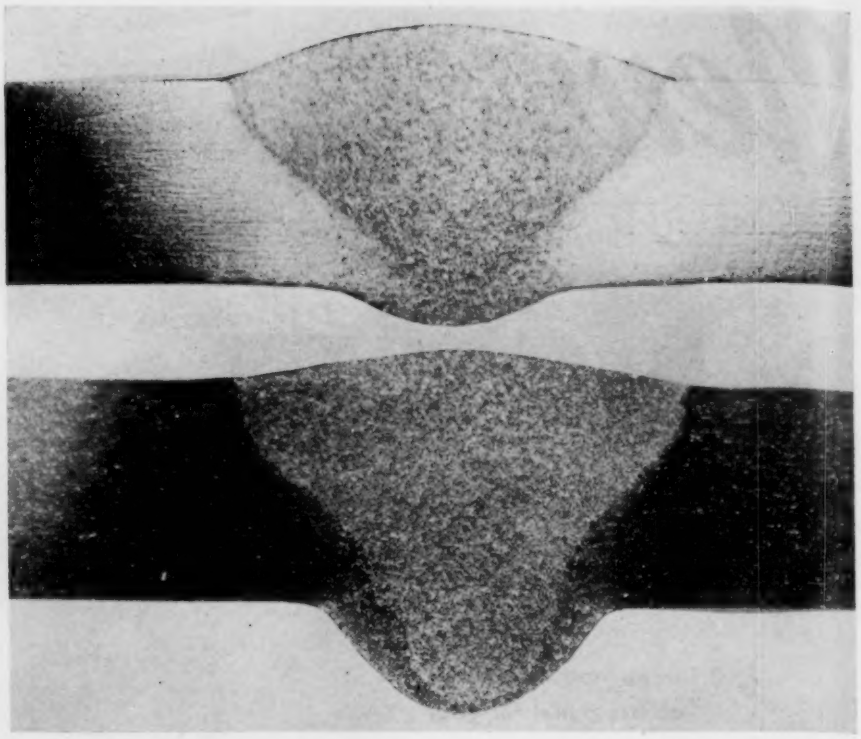


Fig. 6—Macrographs (10 Times Enlargement) of Helium-Shielded Arc Welds on Light-Gage Magnesium. Weld at Top Was Made Without Reverse Bevel; Reverse Bevel Method Used on Weld at Bottom

Good fitup of the work is of primary importance, especially when light gages of metal are butt welded by the free dropdown method. The free dropdown method requires no backing, and the filler metal is allowed to drop through to the underside of the work to form a reinforcing bead on the bottom of the weld. Variations of as little as $^1/_{32}$ in. in the fitup of the edges of the plates will cause metal to drop down unevenly, resulting in a weld of uneven appearance.

The need for clean surfaces in welding magnesium alloys cannot be overemphasized. Magnesium alloys are often given a protective coating by some such method as chrome pickling. If these coatings are not removed before welding, they

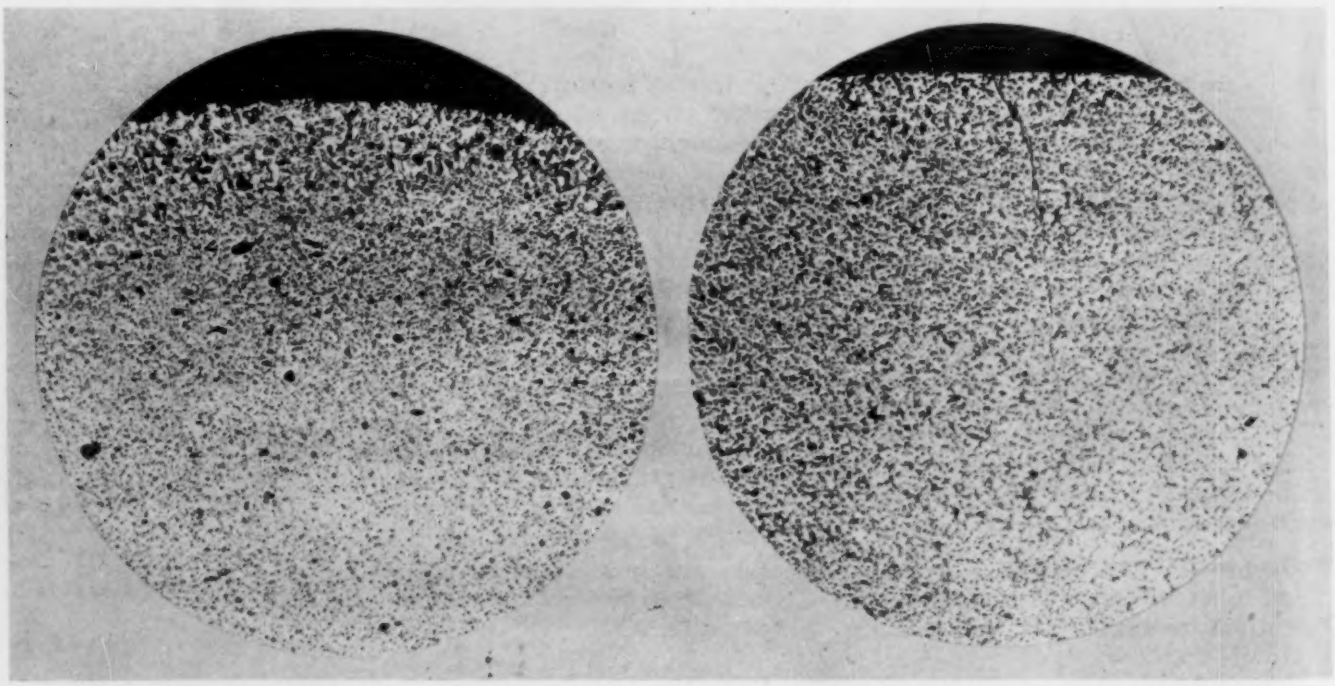
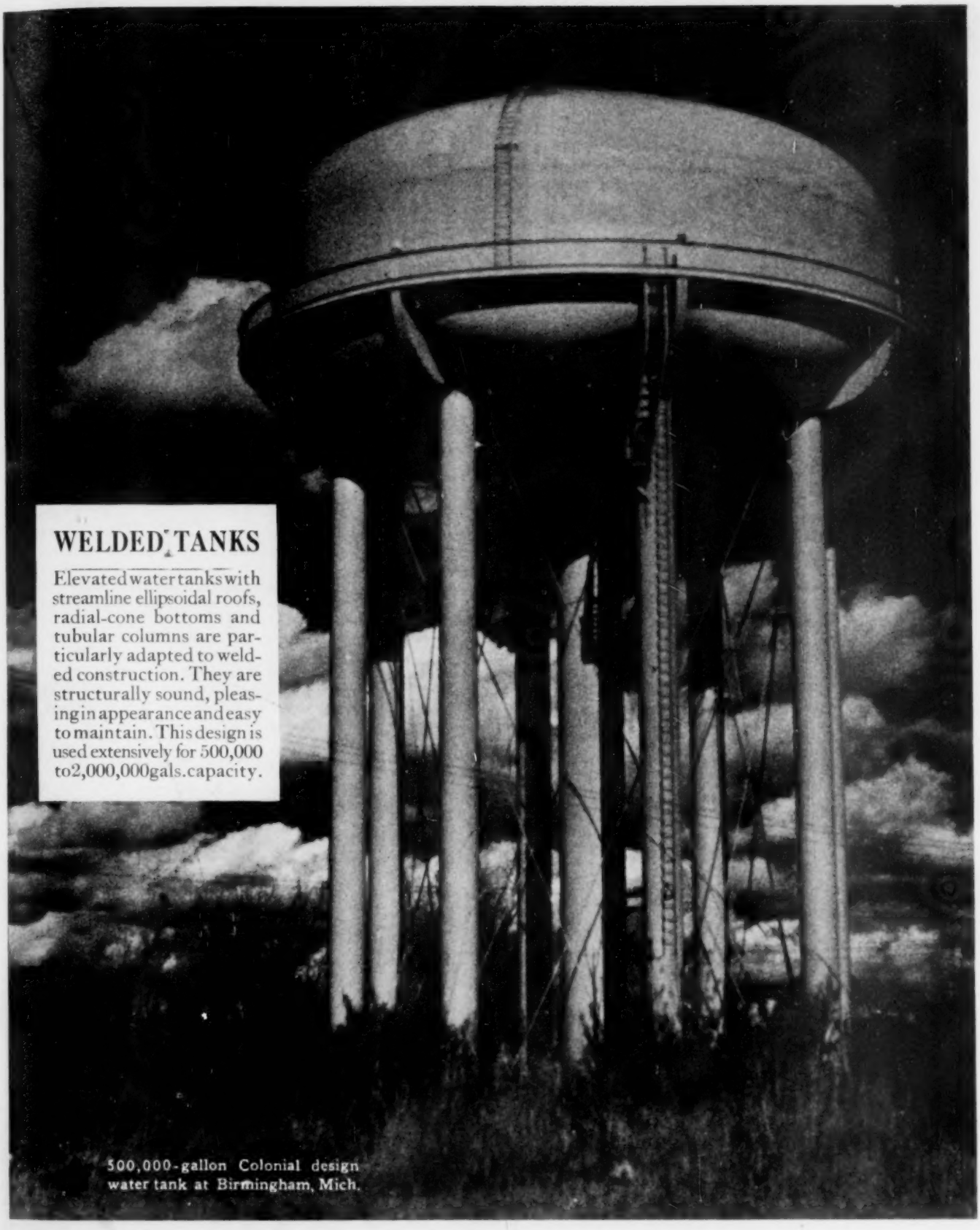


Fig. 7—Two Micrographs (Enlarged 100 Diameters) Showing Roots of Welds in Fig. 6. View at Right Shows Weld Made Without Using Reverse Bevel (Note Crack at Top); View at Left Shows Results Using Reverse-Bevel Method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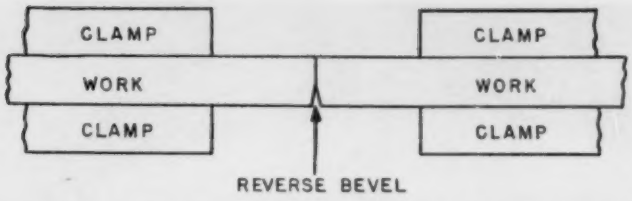

Fig. 8—Drawing of Reverse-Bevel Arrangement Used in Helium-Shielded Arc Welding of Magnesium. Drawing Exaggerated for Illustration Purposes

introduce porosity and inclusions into the welds. Such coatings can be removed most effectively with a wire brush or emery cloth. Unpickled surfaces also should be cleaned before welding because magnesium oxidizes very readily and the oxides remain as inclusions in the welds and also hinder welding.

Backing Plates

Backing plates can be used to shape the reinforcing bead on the bottom of butt joints. Good fitup of the edges, as in the free dropdown method, is not required, for the backing plates limit the amount of metal which can drop down to form the bottom bead. While steel and copper backings have been used on butt joints, stainless steel backings seem to have some advantages, at least in welding thin material. Copper and steel backings tend to freeze the weld metal too rapidly, leaving cold shuts, wrinkles, porosity and oxides in the bottom of the welds. Their high-heat conductivity also requires the use of correspondingly higher welding current. This is a disadvantage from the standpoint of power consumption. It has been discovered recently, however, that the use of low-heat conducting materials remedies this situation. Stainless steels having a heat conductivity about one-third that of ordinary steel have been found to be very successful as backing plate.

Light-gage stainless steel, with a backing groove formed in it and backed up with an asbestos board of some sort, is very effective as a low-heat conducting backing. Asbestos should never be used next to the weld for it contains moisture which it evolves when heated. Water, as has been stated, causes extreme porosity in the weld.

Strength of Magnesium-Alloy Butt Joints

In the welding of magnesium alloy of $^1/_8$-in. gage and lighter, some difficulty may be experienced in obtaining a high tensile strength due to a lack of fusion in the root of some welds. This lack of fusion at the root of the weld is evidenced by a fine line which upon microscopic examination proves to be the exterior of a crack extending into the weld. Tests have shown that welds with this crack have a low tensile strength. It is believed that this crack is the result of a tough refractory oxide skin which forms on magnesium. While the plate edges may appear to have been fused all the way to the bottom of the joint, the oxide film seems to prevent the mingling of the metal at the root of the weld.

Apparently, some mechanical agitation would seem to be required to break up this film. If a very slight bevel is provided at the bottom edges of the plates, the edges will part from one another as they drop down to form the bottom bead. This allows molten filler metal to flow into the gap between the edges, washing them of the oxide, and forming a solid homogeneous structure at the root of the weld. The elimination of the crack by this reverse bevel method has resulted in welds having 90 to 95% of the ultimate tensile strength of the original material.

The macrographs and micrographs in Figs. 6 and 7 show the effect of the "reverse bevel" in eliminating the microscopic crack in welds on light gages of magnesium alloys. Figure 8 shows a drawing of a reverse bevel, exaggerated for illustration purposes.

Conclusion

Applications of manual and automatic helium-shielded arc welding have shown great promise in the field of magnesium alloys. Manual welding at the present time has been more or less limited to the repair of magnesium castings. However, there is little doubt that it will in the near future be used in the welding of structural shapes, especially where welds of short length are used and appearance is not a primary factor. Manual welding is very valuable in that it can be used in places which are inaccessible to automatic equipment.

Automatic equipment, on the other hand, provides a very smooth, uniform weld of excellent appearance and physical properties. It is well adapted to production methods where long-welds and high-welding speeds are required.

Reference

Loose, W. S., and Orban, A. R., "Arc Welding of Magnesium Alloys," THE WELDING JOURNAL, 21 (12); Research Suppl., 598-s to 607-s (1942).

New Filler Metal Specifications

The A.W.S.-A.S.T.M. Committee on Filler Metal has recently completed the **Tentative Specifications for Aluminum and Aluminum-Alloy Metal Arc Welding Electrodes-Serial Designation B184** which is now available in bulletin form. This standard sets forth test requirements for appropriate electrodes to be used in arc welding aluminum and aluminum alloys.

The Tentative Specifications for Iron and Steel Arc Welding Electrodes—Serial Designation A233 have also been revised. This revision is intended to more clearly prescribe the requirements for testing electrodes of the E80, E90, and E100 classifications.

Copies of either standard may be obtained from the **American Welding Society,** 33 West 39th Street, New York 18, N. Y. in the form of 6 x 9-in. leaflets. Price, 25 cents per copy.

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THE AMERICAN WELDING SOCIETY

ACTIVITIES – RELATED EVENTS

NOMINATING COMMITTEE

With the approval of the Executive Committee the President has appointed the following members to constitute the 1943–44 Nominating Committee:

K. L. Hansen, Chairman, Harnischfeger Corp., Milwaukee, Wis.
J. J. Crowe, Air Reduction Sales Co., Jersey City, N. J.
C. J. McGregor, American Steel & Wire Co., Chicago, Ill.
H. O. Hill, Bethlehem Steel Co., Bethlehem, Pa.
George Schneider, Acetylene & Welding Equipment Co., Brooklyn, N. Y.
E. L. Mathy, Victor Equipment Co., San Francisco, Calif.
Walter Thomas, Western Pipe & Steel Co., Los Angeles, Calif.

The By-Laws require that these names be published in the JOURNAL on or before March 1st. The Committee is required to deliver to the Secretary in writing on or before the last Tuesday in May, the names of its nominees for the various elected offices next falling vacant, together with the written acceptance of each nominee.

The purpose of publishing the names of the Nominating Committee in the JOURNAL is to provide every member with an opportunity to make suggestions to the Nominating Committee. To be effective it is essential that these suggestions be sent in at once as, naturally, the Nominating Committee will be required to hold early meetings in order to fulfill its duties as required by the By-Laws.

The offices to be filled are: President, First Vice-President, Second Vice-President (all for a term of 1 year); Treasurer (for term of 3 years); and four Directors (for a term of 3 years). Present incumbents of the first three offices are eligible to re-election for a second term. Present incumbent of office of Treasurer is eligible for re-election, and the incumbents for Directors-at-Large are eligible for re-election, in accordance with Article V of the By-Laws. The Directors-at-Large are selected by the Nominating Committee, with due consideration to geographic distribution.

YEAR BOOK

It is expected that the A.W.S. Year Book will make its appearance sometime in February. The Year Book will no longer be issued as part of THE WELDING JOURNAL. It will be sent only to those members requesting a copy. Paper restrictions have forced the SOCIETY to cut the number of copies printed to one-third the former amount.

The membership data have been brought up to date as of November 30, 1943.

EXECUTIVE COMMITTEE MEETING AMERICAN WELDING SOCIETY

A meeting of the Executive Committee was held on December 17, 1943, in the Board Room, A.I.E.E., 33 W. 39th St., New York, N. Y. The meeting was called to order by President Arnott at 10:20 A.M., with the following present: C. A. Adams, H. C. Boardman, R. W. Clark, O. B. J. Fraser, I. Harter and A. C. Weigel. Others present, by invitation, were E. V. David, Chairman of Convention Committee, W. Spraragen, JOURNAL Editor, and M. M. Kelly, *Secretary*.

Committee Changes

With the approval of the Chairman of the Committees concerned and on recommendation of the President, the following changes and additions to the Standing Committee's personnel were approved:

Substitutions:

Manufacturers Committee: L. W. Smith, National Cylinder Co., replaced J. D. Roberts, of the same company. C. J. McGregor, American Steel & Wire Co., replaced Fred Connell, same company.

Outline of Work Committee: W. J. Conley, The Lincoln Electric Co., replaced B. Brugge, same company.

Additions:

Membership Committee: C. W. Johnston, California Shipbuilding Co., Wilmington, Calif., and R. O. Waldman, Chicago Steel & Wire Co., San Francisco, Calif.

Declination:

Program Committee: Because of pressure of work, Chas. Schenck, Bethlehem Steel Co., Bethlehem, Pa., declined to serve.

Replacements on Board of Directors

It was reported that letter ballot vote of the remaining Directors resulted in the following replacements on the Board of Directors:

R. S. Donald for a two-year term, commencing October 1943, to fill vacancy caused by resignation of J. D. Gordon.
H. C. Boardman for a two-year term, commencing October 1943, to fill vacancy caused by elevation of A. C. Weigel to Vice-Presidency.

A.W.S.-Army Ordnance Committee

The Outline of Work Committee Chairman reported that this Committee is now organized. A two-day meeting was held in New York on November 22nd and 23rd, when the preparation of an inspection manual as the first project to be undertaken by the Committee, was approved. It is intended that this manual shall serve both to the Ordnance Department and producers. It is to be set up as an A.W.S. manual which will be modified by the Army Ordnance Dept. to take care of Army Ordnance inspection and it is intended that the manual will serve as a textbook for instruction of inspectors. The material is to be prepared, if possible, by A.W.S. standardization committees. It is planned to establish a tie-in with the general standardization activities of A.W.S. and Army Ordnance Dept. which can continue after the war. There will be other projects to be considered after the completion of the inspection manual.

Weld Stress Committee—Welding Research Council

In answer to question raised by President Arnott regarding activities of this Committee, Secretary of W.R.C. reported that three investigations were under way under the auspices of the Committee. Others were being considered. Supplementing this work, other investigations in marine construction and armor plate welding were under way under the auspices of NDRC and still others by the Model Basin and Naval Research Laboratory.

Finances

Report on financial operations for fiscal year ended September 30, 1943, was reviewed and special attention drawn by the Treasurer to the fact that the excess of income over expense of $19,121 shown in this statement has been reduced to $7121 by the transfer of $12,000 from the SOCIETY's regular fund to its permanent fund, as authorized by the Board of Directors at its meeting in September 1943.

Consideration was next given to budget for fiscal year commencing October 1, 1943, proposed by the Finance Committee. The Treasurer pointed out that with few exceptions items of income and expense were based on last year's experience, allowing for some improvement.

Year Book

Recommendations of the Publication Committee for publishing the Year Book separate and apart from THE WELDING JOURNAL and in reduced quantity were considered. The bases for these recommendations were explained in the following manner:

Government Restrictions on Use of Paper.—In 1943 government restrictions required a 10% cut on use of

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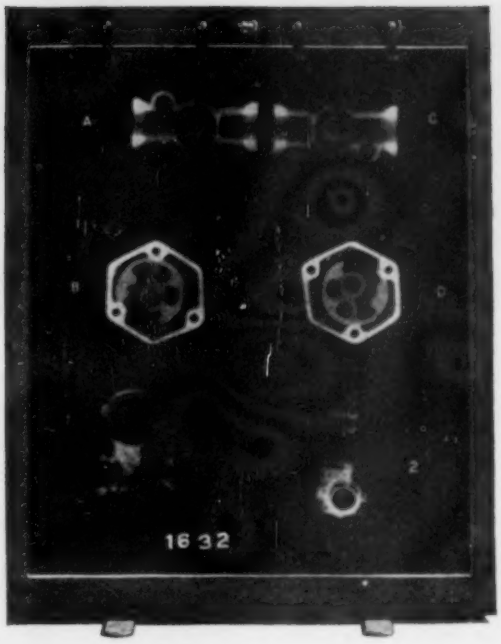

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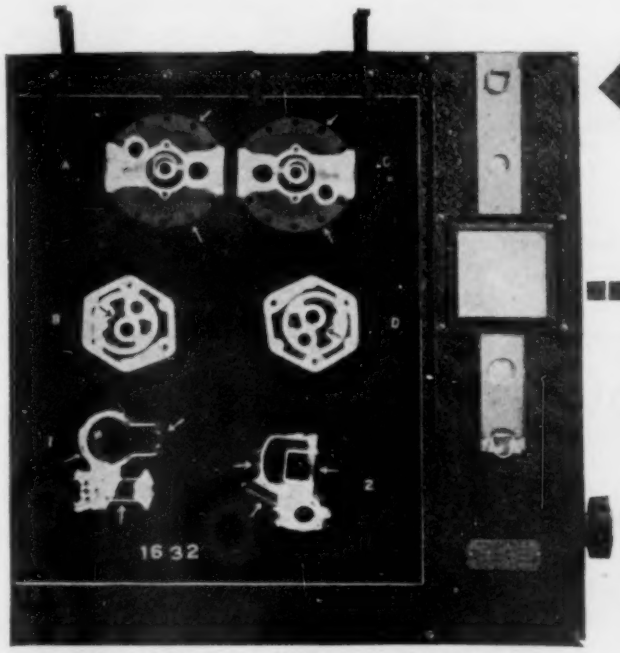

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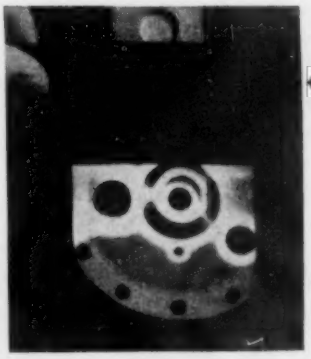

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paper for THE WELDING JOURNAL and in 1944, it required 20% less than in 1942. Although the size of the JOURNAL was cut in 1943, and the weight of the paper reduced from 60 to 50 lb., and the Year Book was not published in December of that year, the SOCIETY's allotment was overrun because of increase in the number of pages and the number of copies of the WELDING JOURNAL published. By printing the Year Book separate, the volume of paper used for the Year Book will be considered as part of our book allotment, which will be safe, as in 1942 the Society printed the large *Welding Handbook*.

There is a saving of approximately $1000 by reducing number of copies from 10,000 to 3500 and in spite of loss in second-class mailing privileges, the cost of mailing 3500 copies is less than it would be by mailing 10,000 as part of THE WELDING JOURNAL.

Other societies have found, by restricting distribution of the Year Book to only those who ask for a copy, they can cut the number of copies to one-sixth of their usual amount. The A.W.S. Publication Committee feels safe in recommending a cut to one-third.

Upon motion, duly seconded, it was voted to approve recommendations of Publication Committee that the publication of the Year Book be separate from THE WELDING JOURNAL; that the number of copies of the Year Book published be reduced from 10,000 to 3500; and that copies of the Year Book be given only to members requesting them.

Certification of Welding Operators

Report of the Public Relations Committee, covering proposal of President of Building Officials Conference of America that the A.W.S. provide means of certifying welding operators and, further, containing recommendation of the Public Relations Committee for the calling of a conference to consider how the A.W.S. might assist in this work, was carefully reviewed.

After deliberation, it was, upon motion, duly seconded, voted to accept the recommendations of the Public Relations Committee and to request the Public Relations Committee to call and conduct the conference proposed therein, with a view to formulating and offering to the Executive Committee recommendations with respect to ways and means by which A.W.S. can render assistance in making the qualification test agencies more readily available and less expensive.

Vacancies in Office of District Vice-President

Acting on recommendation of the Section Officers Conference, held in Chicago last October, that steps be taken to fill vacancies occurring in the office of District Vice-Presidents because of the recently adopted By-Law amendment, providing for seven geographical Districts, President Arnott reported that he had appointed Temporary Chairmen of Districts 2 and 6—H. W. Pierce, Chairman of the Philadelphia Section, as Temporary Chairman of District 2, and Edgar H. Finlay, Chairman of the Kansas City Section, as Temporary Chairman of District 6.

In accordance with the By-Laws, in cases of vacancy the office of District Vice-President can be filled by the Executive Committee of the District at a meeting regularly called, or by letter ballot.

Action of the President in naming Messrs. Pierce and Finlay Temporary Chairmen of Districts 2 and 6, respectively, for the purpose of electing permanent District Vice-Presidents was confirmed by the Executive Committee.

Moisseiff Memorial

Upon motion, duly seconded, it was voted to accept memoir on L. S. Moisseiff, prepared jointly by Jonathan Jones and F. H. Frankland, for transmittal to the family of the late Mr. Moisseiff and for publication in THE WELDING JOURNAL.

It was further voted to thank Messrs. Jones and Frankland for the preparation of this fitting tribute to Mr. Moisseiff.

Mr. Arnott made mention of invitation extended to him as President of A.W.S. to accept membership on a committee being formed to consider and plan a permanent Moisseiff memorial. It was the opinion that participation in this movement

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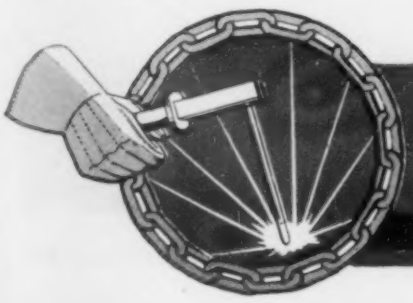

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should be from associates of Mr. Moisseiff in the SOCIETY rather than the SOCIETY itself. The names of the members of A.W.S. who were close to Mr. Moisseiff have been transmitted to the sponsor of the memorial movement.

R.W.M.A. Cash Prize Awards

Invitation from the R.W.M.A. to again act as judges of award of the R.W.M.A. Prize Paper Contest, one emanating from a university source and the other from an industrial source, was considered.

Upon motion, duly seconded, acceptance of the invitation was voted. It was further voted to express appreciation to R.W.M.A. for interest in advancing resistance welding, and, further, to appoint the same judges of R.W.M.A. awards as served in the 1943 Contest, namely, C. A. Adams, *Chairman*, D. H. Corey, P. E. Kyle, J. W. Meadowcroft and J. D. Tebben. Dr. Adams expressed his willingness to accept the Chairmanship of the 1944 Judges of Award.

1944 Annual Meeting

Upon request from the Chairman of the Convention Committee, Mr. David, the A.S.M. invitation to participate in the 1944 National Metal Congress, under the same financial arrangements which have prevailed in the past, was approved and the Convention Committee was authorized to proceed with arrangements for the 1944 Annual Meeting in Cleveland at the time of the National Metal Congress.

LEON S. MOISSEIFF*

Leon S. Moisseiff, one of the world's leading authorities on bridge design, materials and construction, died September 3 1943, at his summer home at Belmar, N. J. By his death the profession of structural engineering lost one of its most notable practitioners and effective leaders. He was consulting or designing engineer on nearly all the greatest bridges built in this country for more than forty years.

Mr. Moisseiff was born in Riga, Latvia in 1872, where he was a student at the Emperor Alexander Gymnasium and the Baltic Polytechnic Institute. He came to this country in 1891 and received his C. E. degree at Columbia University in 1895, following which he was assistant engineer and engineer of design for the Department of Bridges, New York City, until 1915. He then established his independent office as a Consulting Engineer on Bridges and Structural Work, which he maintained with continuing success up to the time of his death. He was author of "Deflection Theory for Design of Suspension Bridges," "Towers, Cables and Stiffening Trusses of Delaware River Bridge," "High Structural Steels for Bridges," "Hudson River Bridge Towers," "Investigation of Cold Drawn Bridge Wire," "Suspension Bridges under Lateral Forces," "Evolution of High Strength Steels in Structural Engineering" and "Theory of Elastic Stability Applied to Structural Design."

The bridge engineering profession often sought his advice and, it has been stated, "many engineers have breathed more easily after their designs carried the stamp of Mr. Moisseiff's approval."

Among Mr. Moisseiff's great achievements were his contributions to the development of the deflection theory of suspension bridges, his investigations of suspension bridge cable wire, and his design work on the Manhattan, Queensborough, George Washington, Bayonne, Triborough, Whitestone, Delaware River, Ambassador, Detroit, Golden Gate, and San Francisco-Oakland Bay Bridges.

He was honored by awards of the Gold Medal of the Franklin Institute, the Norman Medal and the Laurie Prize of the American Society of Civil Engineers, the Egleston Medal from Columbia University and the Modern Pioneer Award of the National Association of Manufacturers.

Mr. Moisseiff was a member of the AMERICAN WELDING SOCIETY, in which he served as treasurer and chairman of the Structural Steel Committee; of the Welding Research Council, of which he was chairman of the Committee on Structural Steel; a life member of the American Society of Civil Engineers, being chairman of its Committee on Design of Lightweight Structural Alloys; of the American Society for Testing Materials, the American Railway Engineering Association, the Joint Committee on Reinforced Concrete, the Committee on Steel Structures Re-

* Resolutions prepared by Jonathan Jones and F. H. Frankland and adopted by the Executive Committee December 17, 1943.

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Variable Core construction permits stepless heat changes while welding. Magic Eye-Pilot indicates when machine is on.

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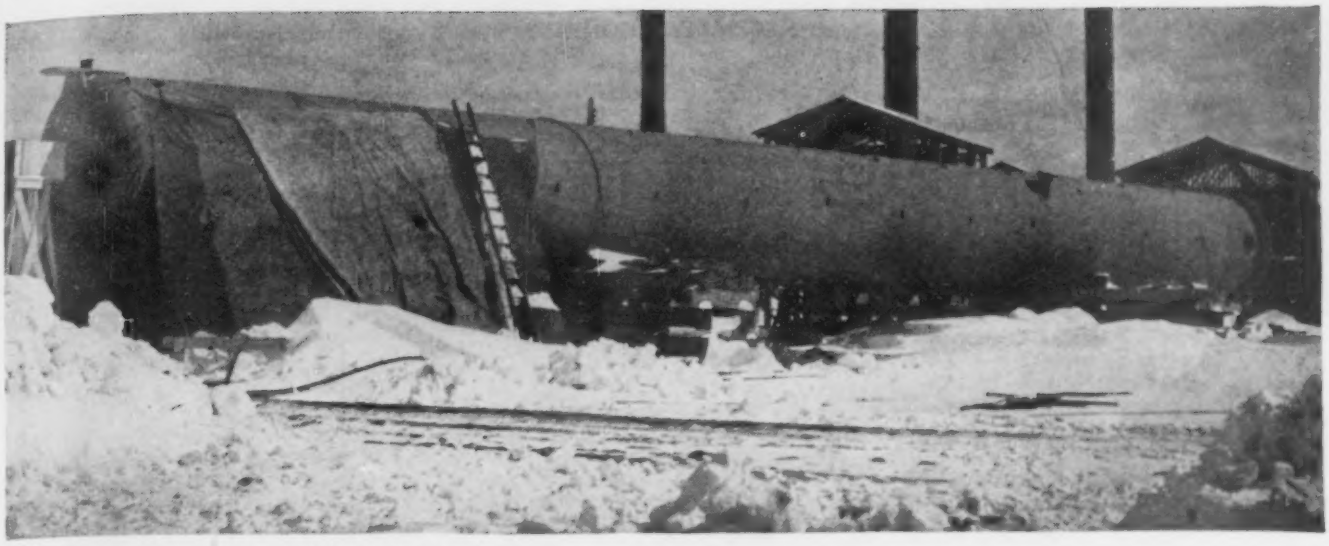
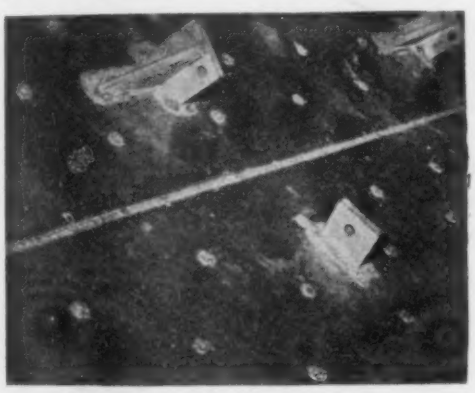
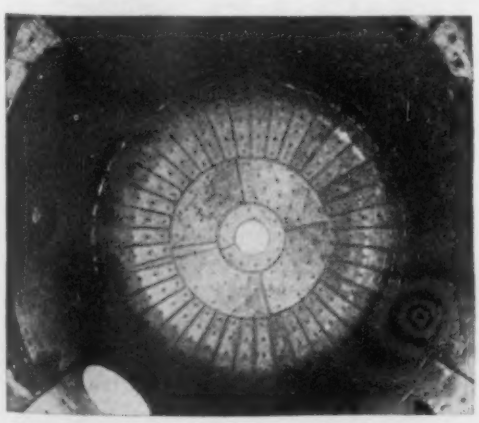


80 ft. x 8 ft. 6 in. cracking tower at large Canadian refinery with "warming tent" rigged up.

18" x 120" sections of .109 Monel sheet shored into place. Plug welds were made with ⅛" diameter No. 130X Monel electrodes with 5/16" holes on 4" staggered centers.



Arc welding at the longitudinal butt joints, and details of fitting and welding around the steel brackets. Bracket welds were overlaid with Monel weld metal.



Close-up of completed lining of the 21-ft top section.

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A 21-foot Monel lining had to be installed in the upper course of a large Canadian petroleum cracking tower in mid-winter.

Faced with the problem of avoiding cracks in the welds at 5° below zero, the engineers contrived a simple and practical solution.

The tower area to be lined was covered with a large canvas, rigged over a timber framework. This provided a dead air space that helped retain heat from a large steam coil placed under the tower. An exhaust fan, seen at the left of the large photo above, provided ventilation.

By this arrangement, an 80° F. temperature was maintained within the working space. The welders worked in comfort, and the welds and steel were protected from thermal shock . . . and the cracking that would have resulted at 5° below zero.

Detailed information covering the installation of plug welded Monel linings will be found in Bulletin T-12, "Welding, Brazing and Soft Soldering of Monel, Nickel and Inconel." For your copy, write: The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

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search of the American Institute of Steel Construction and a member of Zeta Beta Tau and Sigma Xi.

The particular debt of the AMERICAN WELDING SOCIETY and of the welding industry and profession to Leon S. Moisseiff was due to his activity as chairman of the Structural Steel Welding Committee of the American Bureau of Welding, which in September 1931, after a period of painstaking research conducted over a number of years throughout the United States, formulated and published the "Report of Structural Steel Welding Committee" which at once became, and has continued to be, the American authority on the static strength of welded joints. Later, and up to the time of his death, as chairman of the Structural Steel Committee of the Welding Research Council, he was devoting considerable time to the development of testing programs covering many detail aspects of the static and impact strengths of welded joints.

Mr. Moisseiff had a wide range of interests outside of his immediate professional affairs, particularly in English and French literature and in sociology. His keen and penetrating mind, his pioneering spirit and his qualities of sympathy and understanding, extended to others of his profession, as well as his notable achievements in bridge design, insure his high place among the great structural engineers of all time. The world and his profession are immeasurable richer because of Leon Moisseiff's character, abilities and accomplishments.

SUSTAINING COMPANY

Ferranti Electric Limited, Mount Dennis, Toronto 9, Canada, is the Canadian Branch of Ferranti Ltd., Hollinwood, England, which originated in 1889 when Dr. S. Z. de Ferranti designed and built the first 10,000-v. transformers ever made.

The Canadian company specializes in manufacturing transformers and allied equipment such as voltage regulators, etc., and has entered into an agreement with Federal Machine & Welder Co. whereby Ferranti will manufacture Federal resistance welders in Canada.

A.S.T.M. MEETINGS

The American Society for Testing Materials has decided to hold the 1944 Spring Meeting and Committee Week in Cincinnati, Ohio, at the Netherland Plaza, February 28th to March 3rd. The technical feature of the meeting is to be a Symposium on Application and Uses of Synthetic Rubber.

The 1944 (Forty-seventh) Annual Meeting is to be held in New York, N. Y., at the Waldorf-Astoria June 26th to 30th.

HAWKINS LEAVES WPB TO REJOIN P&H

R. L. W. Hawkins, who for the past year was on leave from Harnischfeger Corp. while with the War Production Board as Chief of the Arc Welding Section, is now back with the company. As of January 1st, he will be associated with the P&H branch office in Chicago as welding engineer. Formerly he was assistant sales manager of the welder and electrode division with headquarters at the home office and plant in Milwaukee.

CONTEST RULES FOR TECHNICAL PAPERS ON RESISTANCE WELDING SUBJECTS

1. Donor.—Resistance Welder Manufacturers' Association.

2. Purpose.—To encourage the preparation of outstanding papers dealing with Resistance Welding subjects.

3. Award.—Two prizes of $100 each shall be awarded each year to the authors of two papers, which in the judgment of the Board of Awards, are the greatest original contributions to the advancement and use of Resistance Welding. One of these prizes shall go to the best paper emanating from a university source, that is, either an instructor, student or research fellow at a recognized university. The other award shall be for the best paper emanating from an industrial source, consulting engineer, government laboratory or the like.

4. Eligibles.—(*a*) The contest is open to anyone, without restriction, except as noted below, from the United States, its possessions and Canada. It is also open to any member of the AMERICAN WELDING SOCIETY in any grade from any place in

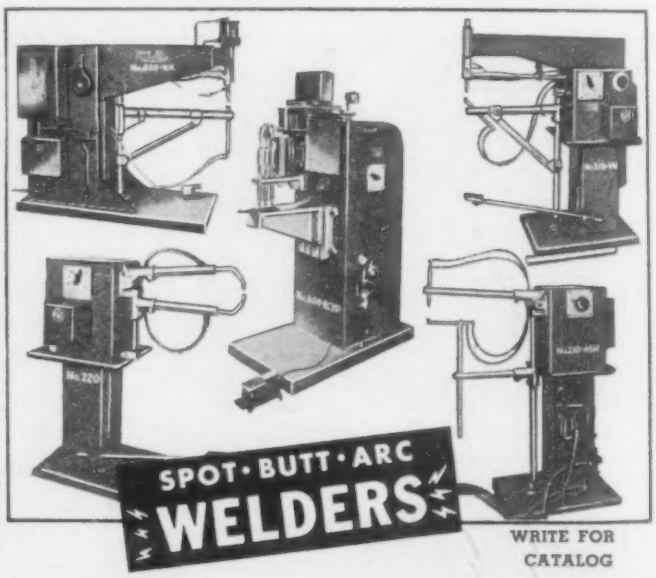
SERVICE ON FABRICATED WELDMENTS

Parts up to many tons welded and shipped with dispatch from private rail siding. Thousands of tons of diesel engine frames alone fabricated for war program.

Specialists in styling of machine tool bases, frames and housings. Submit your drawings. Difficult assignments particularly invited. No obligation.

THE UNITED WELDING CO.
MIDDLETOWN, OHIO

UNITED WELDING
WELDING FABRICATORS OF MODERN DESIGNS



WRITE FOR CATALOG

We manufacture a complete line of resistance spot welders from ¼ to 300 KVA for all types of welding. There is an EISLER WELDER for every purpose.

TRANSFORMERS OF ALL TYPES

WE INVITE CONTRACT SPOT WELDING IN LARGE OR SMALL QUANTITIES.

CHAS. EISLER
EISLER ENGINEERING CO.
779-SO. 13th ST. Near AVON AVE NEWARK, 3 N. J.

15%-30% more production

with the WILSON "BUMBLEBEE"

Here's why the Wilson AC welding machine is boosting welding output by 15% to 30% in many metal-working plants. The "Bumblebee" puts a real sting into the arc – makes it deep and penetrating and almost wholly free of "arc blow". As a result welding output is notably increased while weld quality is considerably improved.

In addition, the "Bumblebee" reduces power costs – using 30% to 35% less power to do the same amount of work as an equivalent DC machine. Built-in capacitors provide improved power factor, which helps to reduce power bills, and permits operation of more welders from existing shop lines without causing overload. Maintenance, too, is easier because the "Bumblebee" has no heavy rotating parts.

The Wilson "Bumblebee" is made in 300 and 500 ampere capacities. Special running gear assembly can be supplied (at slight extra cost) where portability is desired. The "Bumblebee" is also made in "All-Weather" models which have extra moisture protection throughout, as well as automatic low open-circuit voltage controls.

Other Wilson AC welders are available in sizes from 100 to 1000 amperes capacity. There is a complete line of Wilson AC electrodes for every AC welding requirement.

WILSON

WILSON WELDER and METALS CO., INC.

General Offices: 60 East 42nd Street, New York 17, N. Y.

In the U.S.A. WILSON AC WELDERS — *distributed through the Air Reduction Sales Company*

In Canada: G. D. Peters & Co. of Canada Limited • Birks Bldg. Montreal

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WILSON WELDER AND METALS CO., INC.
Department 1656 W. J.
60 East 42nd Street, New York 17, N. Y.

Please send me Catalog ADW-53 giving full details on the WILSON "BUMBLEBEE".

NAME_____

COMPANY_____

ADDRESS_____

CITY & STATE_____

the world. (The only exceptions to the above include anyone who is directly employed by the Resistance Welder Manufacturers' Association.)

(*b*) The contest opened September 1, 1943, and closes midnight, July 31, 1944.

(*c*) All papers submitted in the contest become the joint property of the R.W.-M.A. and the AMERICAN WELDING SOCIETY, who will retain all rights thereto.

(*d*) The AMERICAN WELDING SOCIETY will appoint three judges (to be announced later in the columns of THE WELDING JOURNAL) who will judge the relative merits of the various papers submitted and make the awards accordingly The decision of the judges will be final.

(*e*) For the author or authors to be eligible for this award, the paper shall describe clearly original work done by them or under their supervision on resistance welding in any of its aspects by any method or process. The paper shall be a full disclosure of the subject. The paper shall contain no statement which is unethical advertising or sales promotion. The paper may contain statements of fact including the names of either individuals or organizations of any kind, commercial designations, trade names, etc.

(*f*) Minimum length requirement—2500 words.

(*g*) Papers submitted in this contest may, at the discretion of the editors of THE WELDING JOURNAL, be published in the JOURNAL, or any other technical publication, at any time the editors of the JOURNAL see fit and not necessarily waiting until the expiration date of the contest.

(*h*) All papers must be typewritten, single spacing, written on one side only of blank white paper. Photographs, charts, graphs, etc., may either be attached directly to the copy or may be detached, in which case they should be clearly identified with figure numbers, captions, etc.

(*i*) Papers which are to be presented at the Annual Meeting of the AMERICAN WELDING SOCIETY in October may also be entered in this contest in which case a draft or copy of the paper must be filed with the WELDING SOCIETY not later than July 31st.

REGULATIONS GOVERNING THE AWARD OF THE LINCOLN GOLD MEDAL

1. Donor.—J. F. Lincoln, President, The Lincoln Electric Co.

2. Purpose.—To encourage the presentation before the AMERICAN WELDING SOCIETY of papers which are effective in promoting the use of welding.

3. Award.—The medal shall be awarded each year to the author or authors of the paper which in the judgment of the Board of Awards is the greatest original contribution to the advancement and use of welding.

4. Eligibles.—(*a*) For the author or authors to be eligible for this award, the paper shall describe clearly original work done by them or under their supervision on welding in any of its aspects by any method or process.

(*b*) The paper shall be a full disclosure of the subject.

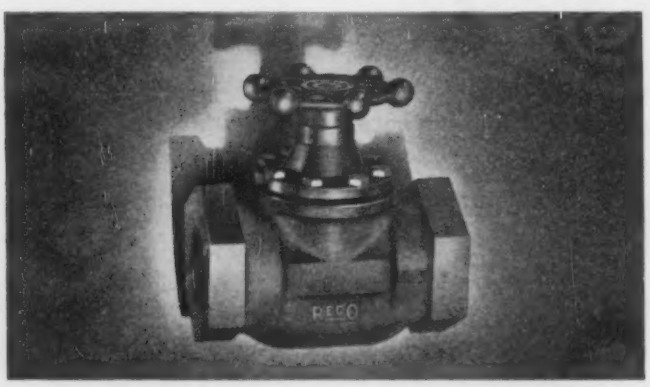
(*c*) The paper shall contain no statement which is unethical advertising or sales promotion. The paper may contain statements of fact including the names of either individuals or organizations of any kind, commercial designations, trade names, etc.

(*d*) Papers having more than three authors shall not be considered for this award.

(*e*) Any one may be an author of a paper considered for his award whether or not a member of the AMERICAN WELDING SOCIETY.

(*f*) For the author or authors to be eligible for this award, the paper shall have been published in an issue of THE WELDING JOURNAL during a twelve-month period ending with the July issue before the Annual Meeting, and also, the paper shall have been presented or scheduled for presentation either at a meeting of the AMERICAN WELDING SOCIETY or a meeting of any division or section of the SOCIETY.

5. Presentation.—The medal, bearing on the reverse side the name of each author of the paper, together with a suitable certificate, shall be presented at a session of the Annual Meeting of the AMERICAN WELDING SOCIETY during the year for which the award is made by the Chairman of the Board of Awards or by a member of the SOCIETY designated by the Chairman. Each author of the paper for which the award is made shall receive a medal and a certificate and the medals and certificates shall be duplicates.



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REGO Gas Plant Equipment to be safe, must be made of brass and other critical metals.

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TO SALVAGE CRITICAL MATERIAL AND GREATLY INCREASE PRODUCTION ALL ALONG THE LINE

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2. Cleaning and grinding are unnecessary with "York's 77".
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3349 OGDEN AVENUE • CHICAGO, ILLINOIS

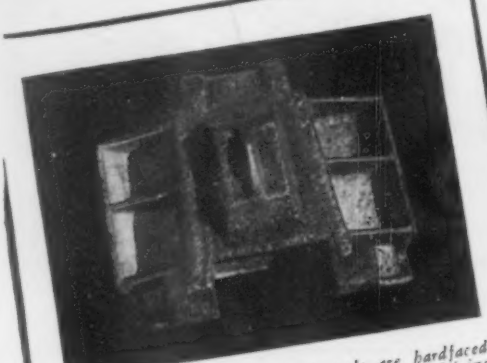
WEAR PROOFING
for WEARING PARTS

IT'S common sense that ANY part subjected to abrasion is going to wear—and sooner or later wear necessitates replacements. With new parts so hard to get, Stoody Alloys are more important than ever for keeping your equipment in operation. Their big advantage over ordinary rods or electrodes is that parts reclaimed with Stoody Alloys invariably outlast new, unprotected equipment! Applications can be made by either acetylene or electric methods and rebuilding cost is usually a fraction of a new part cost.

Illustrated are a few typical examples where Stoody Alloys are being used to save replacements and reduce operating costs.

COAL CUTTER BITS—Bits hard-faced with Borod, are saving one company over $1,800 per year. One pound of ⅜" bare Borod costs only $5.50 and will tip the points of 4,000 bits!

VALVES—*Ordinary exhaust valves, whether new or worn, give up to four times more service when hardfaced with Stoody 6. A typical example is this valve above . . Hardfaced after 25,000 miles, it was again put in service to run an additional 96,000 miles! Other valve applications include gates, globes and angles.*



SHOVEL PADS—*Shovel track pads are hardfaced after wear has developed between pads and driving tumblers. When wear is severe pads are rebuilt to within ⅛" of original size with high carbon electrodes, then protected with a final layer of Coated Stoody Self-Hardening. A $40.00 shovel pad weighing over 100 lbs., can be rebuilt with only 6 to 8 lbs. of metal in 2 to 3 hours. Hardfaced pads outlast new, unprotected pads two to one!*

Our 16 page booklet "Hardfacing—Industry's Weapon Against Wear" describes Stoody Alloys, illustrates dozens of typical Stoody hardfacing applications and recommends proper rods for many industrial uses. Write for your free copy!

STOODY COMPANY
1135 W. SLAUSON AVE., WHITTIER, CALIF.

STOODY HARD-FACING ALLOYS
Stop wear . . . Eliminate Repair

STANDARDS MEETING

The American Standards Association on December 10th at the Hotel Roosevelt, New York, N. Y., celebrated a quarter century of service to industry and the government in the field of standards.

It was announced that the Board of Directors of the Association had authorized participation in an Allied Nations Standards Body. The organization of such a body has been discussed informally for a number of weeks between the British Standards Institution, the Canadian Engineering Standards Association, the American Standards Association and also with key governmental agencies in the three countries.

The function of the organization is to "spark plug" cooperation between the allied belligerent countries in standardization matters as an aid to production and use.

The object is to secure the maximum possible coordination of standards necessary for the war effort and the immediate postwar period.

A skeleton staff will be provided with offices in London and in either New York or Washington.

Officers for 1944, announced at the meeting, are: Henry B. Bryans, Executive Vice-President, Philadelphia Electric Co., *President-elect;* George S. Case, Chairman of Board, Lamson and Sessions Co., re-elected *Vice-President;* H. S. Osborne, Chief Engineer, American Telephone & Telegraph Co., re-elected *Chairman, Standards Council,* which is in charge of all A.S.A. technical work; E. C. Crittenden, Assistant Director, National Bureau of Standards, re-elected *Vice-Chairman, Standards Council.*

Clifton E. Mack, Director of Procurement, United States Treasury Dept., and the man in charge of Government lend-lease purchasing, was guest speaker at the meeting. Mr. Mack's address dealt with the use of standards to cut costs in Government, and how standards are helping this country to deliver to our allies in sufficient quantity and in good condition the products that are helping to win the war.

R. E. Zimmerman, Vice-President, U. S. Steel Corp. and retiring president of the American Standards Association, spoke on postwar changes and developments in use of standards in this country and in international trade.

H. S. Osborne, Chairman of the Standards Council, reported that in the past twelve months the American Standards Association had approved 119 standards.

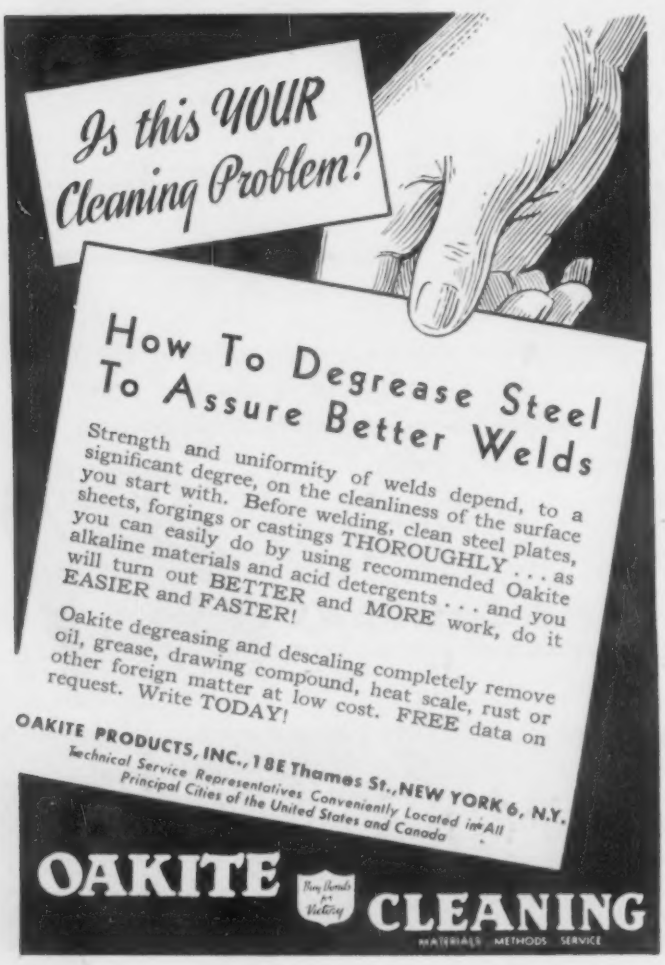
COLLECTION OF SPECIMENS OF STAINLESS STEEL SUSPECTED OF HAVING SUFFERED STRESS CORROSION CRACKING IN SERVICE

Subcommittee 2-d of the High Alloys Committee of the Welding Research Council of the Engineering Foundation is engaged in a study of the stress corrosion cracking of stainless steels.* As an aid in this investigation, the committee is anxious to secure specimens of stainless steel that are suspected of having suffered stress corrosion cracking in service, together with detailed information on the conditions surrounding each application. Specimens may be forwarded directly to the Chairman of Subcommittee 2-d, Mr. M. A. Scheil, in care of the A. O. Smith Corporation, Milwaukee 1, Wis.

With the specimens, as much as possible of the following information should be furnished:

1. Composition of the steel.
2. Nature of heat treatment prior to service.
3. Form of material represented by specimen, e.g., plate, sheet, tube.
4. Location of specimen in service relative to welds, liquid level, etc., preferably illustrated by sketch.
5. Kind of weld, if any, and composition of welding rod.
6. Nature of chemical process involved.
7. Nature of process unit, e.g., evaporator, condenser, etc.
8. Chemical composition of liquid, or liquids, handled, including acidity or pH and minor con-

* See Scheil, M. A., Zmeskal, O., Waber, J., and Stockhausen, F., "First Report on Stress Corrosion Cracking of Stainless Steel in Chloride Solutions" (Monthly Report), THE WELDING JOURNAL RESEARCH SUPPLEMENT, VIII (10), 493-s to 504-s.


Is this YOUR Cleaning Problem?
How To Degrease Steel To Assure Better Welds
Strength and uniformity of welds depend, to a significant degree, on the cleanliness of the surface you start with. Before welding, clean steel plates, sheets, forgings or castings THOROUGHLY . . . as you can easily do by using recommended Oakite alkaline materials and acid detergents . . . and you will turn out BETTER and MORE work, do it EASIER and FASTER!
Oakite degreasing and descaling completely remove oil, grease, drawing compound, heat scale, rust or other foreign matter at low cost. FREE data on request. Write TODAY!
OAKITE PRODUCTS, INC., 18E Thames St., NEW YORK 6, N.Y.
Technical Service Representatives Conveniently Located in All Principal Cities of the United States and Canada
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Time Buys Victory
CLEANING
MATERIALS · METHODS · SERVICE

Time Counts – Gas cut and Weld with
Shawinigan Carbide
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FOR VICTORY BUY UNITED STATES WAR SAVING BONDS STAMPS
SHAWINIGAN PRODUCTS CORPORATION
EMPIRE STATE BUILDING, NEW YORK 1, N.Y.

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them

The Trade-Name is "ANTI-BORAX"

Ask for Them ***Unequalled for Quality***

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; No. 16 Silver Solder Paste Flux.

ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana

NO – not just a weldor's dream!

A TRIED and PROVED REALITY

Tweco "Hol-Grip Jr." Holder

7½ ounces — 7" length overall — $\frac{1}{16}$" through $\frac{5}{32}$" electrodes — 150 Amperes — Fully insulated

This little holder (shown actual size above) packs a real wallop on the production "firing line." Wherever airplanes are built, you find TWECO "HOL-GRIP JR." Electrode Holders putting the axe to the axis with more planes — better planes — arc-welded planes.

TWECO "HOL-GRIP JR." is designed for light, high-speed production welding Ideal for women weldors with its ease of operation, light weight, compactness and streamlined, aerated full-insulation.

TWECO PRODUCTS

Ask your distributor for TWECO "HOL-GRIP JR." Sells for only $3.75. In dozen lots, $3.40. Write for Bulletin No. 1943-GJ showing complete line of TWECO PRODUCTS including other models of TWECO Holders, Ground Clamps, Cable Lugs, and Cable Connectors.

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stituents, especially halogen compounds, such as chlorides.

9. Maximum, minimum and average temperatures of operation.
10. Operating pressure or vacuum.
11. Magnitude and range of service stresses, if known, including information on any cyclic fatigue stresses and restrained thermal expansion stresses.
12. Length of time material was used before cracking occurred.
13. Experience with other alloys in same service.

RANSOME WELDING POSITIONERS NOW AVAILABLE THROUGH WORTHINGTON DISTRICT OFFICES

Heavy demands for welding positioners used to help speed the war effort in shipyards, ship repair bases and vital war industries, have made essential the establishment of easier ordering and service information facilities.

The war effort has greatly benefited through the use of welding positioning equipment by those industries producing welded products.

By attaching the work to the positioner table top, the operator can easily move it to the most desirable position for all downhand welding. Because of this position, many welds can be made in one pass using a heavy rod that used to require two or three when the work was not properly positioned. The results are smoother, stronger welds produced in much less time.

The Ransome Machinery Co., recognized as one of the leading manufacturers of welding positioning equipment, is now a wholly owned subsidiary of Worthington Pump and Machinery Corp. Ransome welding positioning equipment is now more widely available to industries through Worthington district offices in all principal cities.

METALS DATA BOOK

Metals and Alloys Data Book, by Samuel L. Hoyt, Technical Adviser of Battelle Memorial Institute, formerly Research Metallurgist for General Electric Co. A collection of the latest most authoritative data covering all industrial metals and alloys, presented in the briefest, most usable form—in tables.

Here's a book containing 340 tables of authoritatively compiled engineering property data on steels, alloy steels, NE steels, steel castings, cast irons, wrought iron, heat- and corrosion-resistant casting alloys, aluminum, copper, nickel, tin and zinc alloys, rare metals and many others. In these tables the latest data pertaining to such properties as tensile strength, hardness, thermal expansion, creep strength, high temperature behavior, work-hardening, endurance limit, yield strength hardenability, corrosion resistance, impact values, etc., are instantly available. Here are the records of all metal properties between two covers.

The Data Book is invaluable for design, materials, mechanical, metallurgical and chemical engineers, research men, engineers, inspectors, and others in shop, mill, or in the field; producing, designing, fabricating or otherwise using metals, alloys and metal products.

All material contained is especially arranged for speedy reference in busy plants. Indexed both alphabetically, as well as by subject, all information pertaining to the physical and chemical properties of any metal or alloy may be located with a minimum of effort.

Published by Reinhold Publishing Corp., 330 W. 42nd St., New York 18, N. Y. Price $4.75.

THE EUTECTIC WELDER

This monthly publication will be devoted to welding news, design, metallurgy methods, cost analysis, useful tools and helpful hints. A request written on company letterhead addressed to Eutectic Welding Alloys Co., 40 Worth St., New York 13, N. Y., willbring *The EUTECTIC Welder*, free, to anyone interested in the advancement of welding.

SAFETY PAMPHLET

An illustrated booklet entitled *Right on the Nose*, which explains in detail the quickest, easiest methods of adjusting nonprescription industrial safety goggles so that workers can wear them in comfort, has been published by the American Optical Company of Southbridge, Mass. Free copies can be obtained by writing the concern direct.

The booklet was prepared for safety directors, medical directors, or other persons assigned the job of fitting goggles. Objective behind the booklet is to help prevent eye accidents caused by workers refusing to wear improperly fitted safety goggles which may be uncomfortable to wear.

A training film on the same subject and bearing the same title has also been produced by American Optical for goggle fitters. This new sound motion picture, 16-mm. film, is available on a free loan basis, and prints can be secured direct from the company.

SCIENTIST LEARNS WELDING AT 75

Though he retired from the directorship of the General Electric Research Laboratory in 1933, Dr. Willis R. Whitney still engages actively in research. Recently he became interested in some problems connected with welding. With his characteristic desire to master the fundamentals before studying a subject, he went to an expert and learned to become a welder himself. He is seen here on the day following his 75th birthday, welding an atomic-hydrogen welding torch.

LOW-TEMPERATURE BRAZING NEWS

The latest issue of *Low-Temperature Brazing News* published by Handy & Harman, 82 Fulton St., New York 7, N. Y. covers the use of Easy-Flo Brazing Alloy in the production of guns. Copy is available on request.

APPLIED SAFETY ENGINEERING

Applied Safety Engineering by H. H. Berman and H. W. McCrone, 1st ed., published by McGraw-Hill Book Co., Inc., New York and London. Price $2.00. Industrial safety engineering has assumed national importance as a profession. With the public's attention focused on the annual accident toll and its impact on production, safety engineering methods are under constant discussion and study.

A consequence of the increased attention to the accident problem has been the demand for additional Safety Engineers. To meet the demand thousands of men and some women have been trained in the

Castolin Eutectic
SAVE SCARCE BRONZE WELDING RODS!
EUTECTIC+LOW TEMPERATURE WELDING
THE NEW PROCESS — IDEAL FOR REPAIRS & RECLAMATION ON CAST IRON
NO. 14 -- GAS WELDING NO. 24B -- AC-DC METALLIC ARC
Machinable • Color Matching • No Stresses • No Distortion
AVAILABLE ON PRIORITY A-9
Write for Welding Data Book E *Reg. U. S. Pat. Off.
EUTECTIC WELDING ALLOYS COMPANY • 40 WORTH STREET • NEW YORK

FIRST IN WAR . . .
FIRST IN PEACE . . .

The same qualities which make **CHAMPION** electrodes a leading choice today guarantee their continued popularity for postwar production. The name **CHAMPION** stands for maximum deposit efficiency, good penetration and easy slag removal. Sound non-porous weld metal is a certainty when using **CHAMPION** electrodes.

Champions always command respect and **CHAMPION** electrodes have won the confidence of all who use them.

Use a **CHAMPION** Black Devil Electrode for down hand welding.

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Use a **CHAMPION** Gray Devil straight polarity for fillet welds.

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Use a **CHAMPION** Blue Devil for vertical and overhead welding.

THE CHAMPION RIVET CO.

11400 **HARVARD AVE.**, *Cleveland, Ohio*

EAST CHICAGO, IND.

past few years in the basic principles of industrial accident prevention. Some of these recently trained individuals have attained outstandingly successful results by applying their training, while others have not succeeded so well; a few may have become discouraged and may even view present safety methods with skepticism.

REGULATOR PAMPHLET

Victor Equipment Company, 844-54 Folsom St., San Francisco, has issued a bulletin, covering their line of "Gas-O-Dome" Regulators. This bulletin is available, free of charge, to all interested persons.

LOW-TEMPERATURE WELDING

The Eutectic Welding Alloys Co., 40 Worth St., New York 13, N. Y., has issued a comprehensive technical pamphlet for use with oxyacetylene, gas torches, metallic arc, carbon arc, atomic hydrogen, induction, resistance and furnace.

This publication is "brim-full" of facts on low-temperature welding for fabrication, salvaging and general maintenance in all types of war industries and postwar applications. There are numerous helpful hints on how to increase welding efficiency on all metals with Eutectic low-temperature welding as well as complete instructions for easy, low-cost salvaging of vital war-production tools. A special chart of unusual interest has been devised to simplify rod selection and use.

WAR MANPOWER COMMISSION CRITICAL OCCUPATIONS

The jobs of Electric Arc Welder and High Pressure Vessel and Piping Welder have been added to the List of Critical Occupations, the War Manpower Commission announced recently.

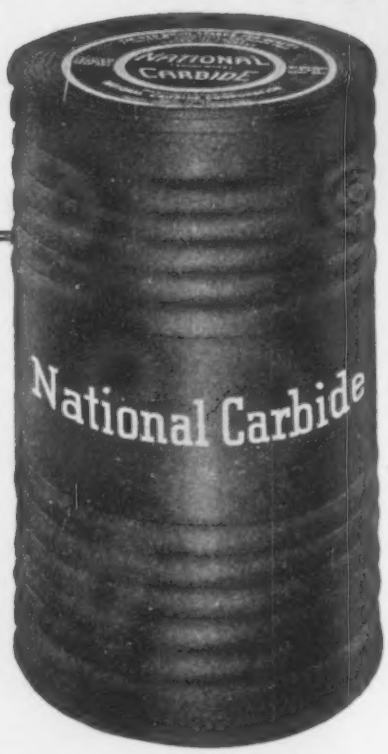
WMC pointed out that the only persons under this title are those who use an electric welding apparatus in welding metal parts in the fabricating, erecting or repairing of pressure vessels of carbon or alloy steel fabricated in conformance with codes of the American Society of Mechanical Engineers and the American Petroleum Institute. It does not include welders working on any pressure vessels that do not bear the official stamps of approval of the American Society of Mechanical Engineers.

Added to the Essential Activities List under Group No. 14, Finishing of Metal Products, is the activity, "Heat Treating."

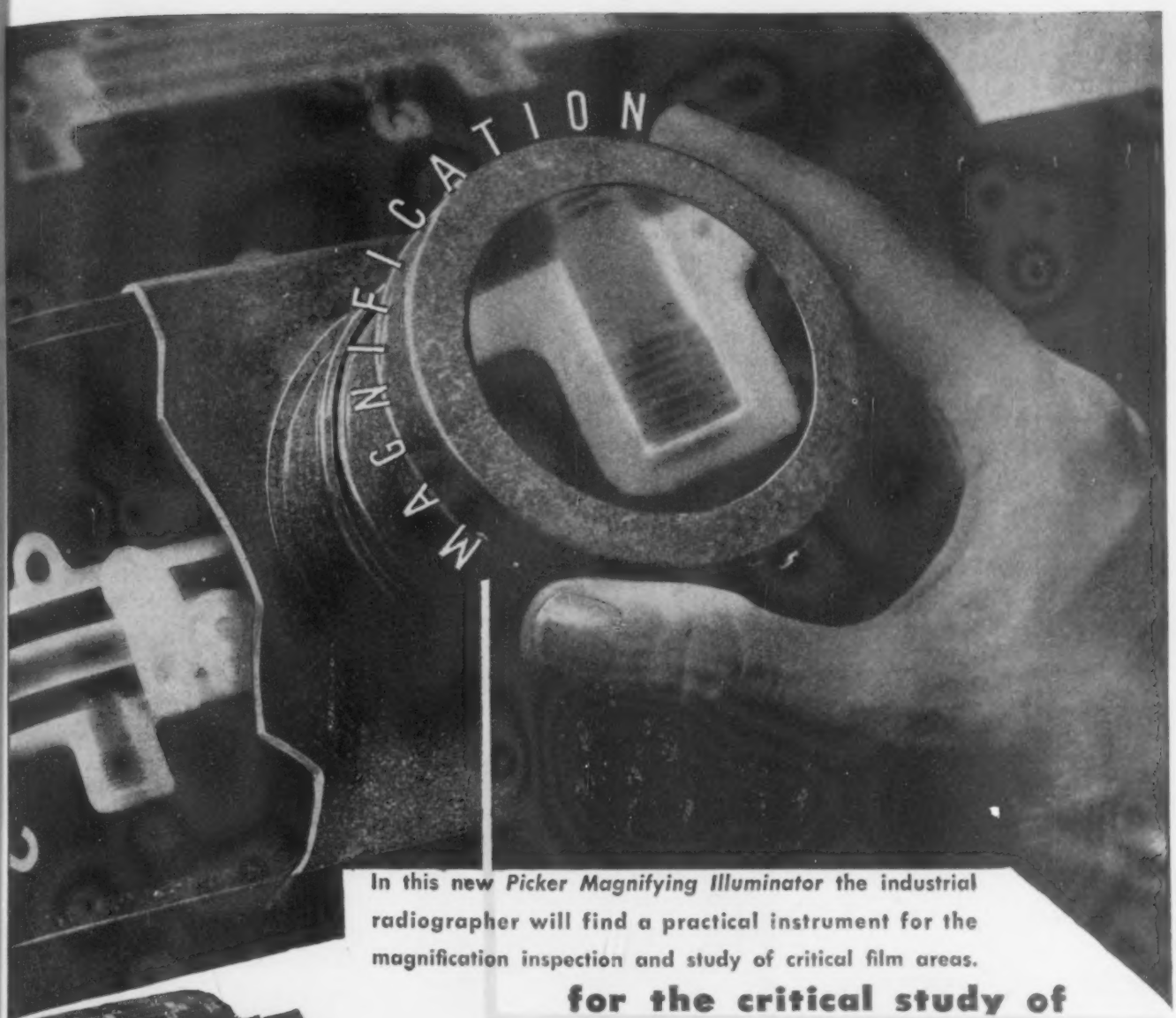
Organization Dinner Meeting of Louisville Section on October 26, 1943

National
Carbide
IN THE RED DRUM

EFFICIENT
ECONOMICAL
DEPENDABLE



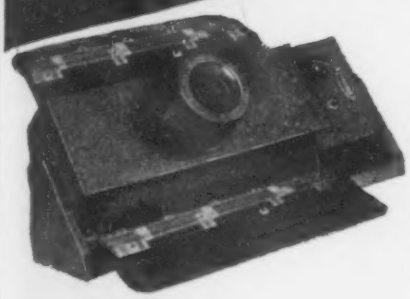
FOR WELDING and CUTTING
Use National Carbide in the Red Drum
60 E. 42nd St. NATIONAL CARBIDE CORPORATION New York, N. Y.



In this new *Picker Magnifying Illuminator* the industrial radiographer will find a practical instrument for the magnification inspection and study of critical film areas.

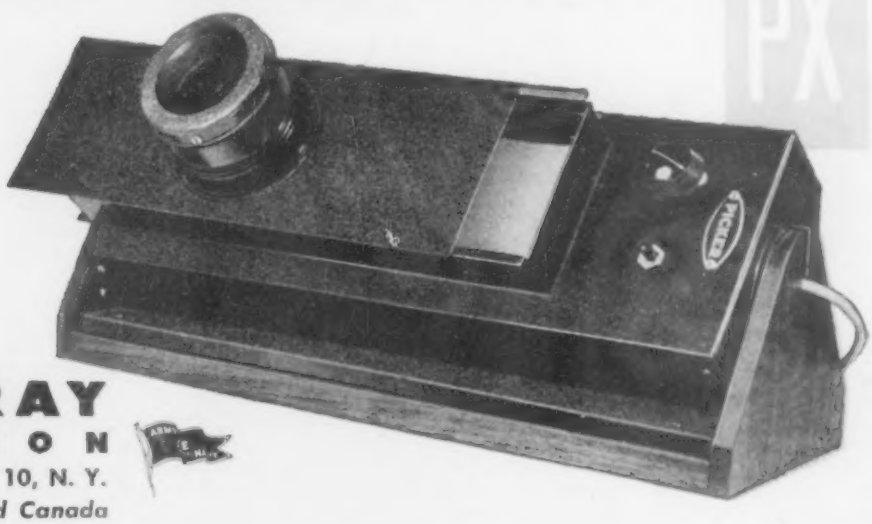
for the critical study of industrial radiographs

A magnifying factor of 2½X provides ample power for minute study of spot weld radiographs, or those exhibiting porosity, shrinkage cracks, gas inclusions, and similar faults. Picker Bulletin 1143 gives details, specifications, prices.



PICKER MAGNIFYING ILLUMINATOR

Telescopic lens mount adjustable to individual vision...variable intensity fluorescent illumination . . . sliding baffle hood . . . adjustable viewing angle . . . takes any length film up to 14" wide...operates on AC or DC.



PICKER X-RAY CORPORATION

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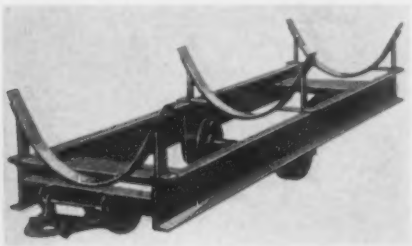
NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

MODEL BAR-STOCK TRUCK

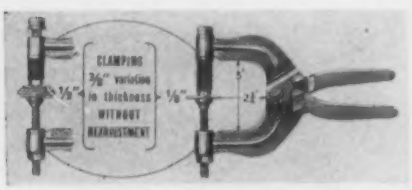
A new model truck designed for the specific purpose of handling bar stock has just been announced by Rose Manufacturing Co., 12400 Strathmoor, Detroit, Mich.



A balanced, four-wheel type that features maneuverability because of the nature of the load that it carries, it must necessarily turn corners sharply (can be turned around in its own length like a turntable). It is furnished with two heavy-duty swivel casters front and rear and heavy-duty steel wheels, equipped with Hyatt roller bearings. The frame of this new model 6018 bar-stock truck is built up of structural steel members securely welded. Trailer coupling on the front.

NEW TOOL CLAMPS

The Detroit Stamping Co., 322 Midland Ave., Detroit 3, Mich., announces the addition of a new portable toggle clamp to its line of De-Sta-Co products. This clamp, known as De-Sta-Co Clamp No. 470, with Pressure-Matic feature, is especially recommended by the manufacturer for use on sheet metal and other work where the individual parts to be clamped vary in thickness, up to as much as $^{3}/_{8}$ in. on various locations of the same fixture group.

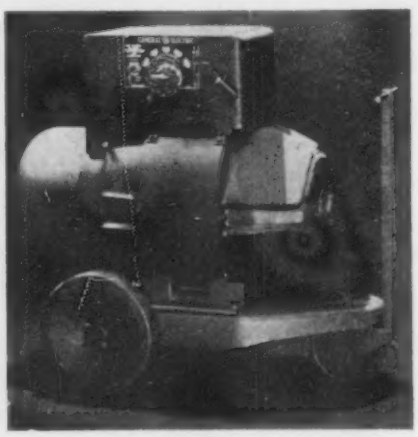


The spring you see fitted onto one of the adjustment spindles provides for this $^{3}/_{8}$-in. variation in clamping thicknesses without need for readjustment of spindle; for example, you may clamp $^{1}/_{8}$ in. thickness or up to $^{1}/_{2}$ in. thickness without readjusting the gap; in fact, any distance within the capacity of the clamp allows for this $^{3}/_{8}$-in. variation without any readjustment.

Also the 3-in. wide throat of this new clamp provides capacity to handle a much greater than average range of work and thereby further increases its usefulness. The improved swivel foot permits clamping angles and other odd shapes securely; may be used for clamping metal, wood or plastic parts, for riveting, welding, gluing or endless other production operations.

IMPROVEMENTS IN D-C ARC WELDERS

Improvements in its line of direct-current, single-operator arc welders, Type WD-30 series, have been announced by the Electric Welding Div. of the General Electric Co. In addition to retaining all the desirable features of this well-known line, these welders are now equipped with two new control dials and a redesigned driving motor. The control dials permit the welding current to be preset without the aid of a volt-ammeter, and the driving motor is designed to give exceptional resistance to the weather when the welding machine is operated outdoors.



Large in size and conveniently located, one of the control dials is calibrated in terms of electrode size. The operator simply sets this dial to correspond to the size of the electrode being used. The other dial indicates the range of welding current available for use under these conditions. The operator presets the welding current merely by rotating a pointer to whatever amperage he wishes to use. Clear, easily read calibrations facilitate quick, accurate operation of both dials.

While basically the driving motor is the same as that previously furnished with these welders, it is equipped with heavier insulation and has special weather-protective features. Enlarged intake openings for ventilating air keep the air velocity low enough to prevent rain and snow from being drawn in, while a large baffle back of the openings prevents water from splashing into the motor. The insulation of the motor windings is very heavy, and accelerated life tests show that this new insulation is far more resistant to deterioration from salt spray than the insulation previously furnished.

ARC WELDING OF THIN AIRCRAFT METALS PRACTICAL

Welding of thin metals—so much of which is being done by aircraft builders—requires small electrodes. Low-welding currents are also necessary to keep from burning the thin sheet, according to Westinghouse engineers. Under these conditions, the a.-c. arc becomes unstable and tends to go out easily, frequently spoiling the weld.

Gas has been used to some extent for this sort of work—it is fast but more expensive. D.-c. welding was not feasible because of arc-blow difficulties. Not only that, the greater penetration of d. c. often led to burning through the thin metal.

The problem was solved by superimposing a high-frequency voltage wave (about 250 kilocycles) on the welding current. This high-frequency voltage keeps the arc steam ionized during the reversals of low-frequency (60-cycle) welding current. Functioning as an arc stabilizer, the high frequency provides firm control of very small welding currents. This new welding development has greatly expedited plane production and the manufacture of other devices from thin-gage metals.

WELDING MACHINE

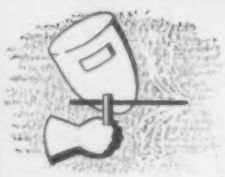
The Libby Welding Co., 2700 E. 14th St., Kansas City, Mo., announces a line of portable gasoline-driven welding machines.

The machine shown (Model LWL) is made up of a Waukesha Model FCU gasoline motor driving a 200-amp. Lincoln "Shield Arc" welding generator. These units with tool boxes are mounted on a welded structural shape chassis equipped with rubber tires and a towing attachment. The power required to move the machine is such that it can be easily moved by hand. A lifting hood is provided for placing the machine on or removing it from a truck or freight car.

The machine base has an over-all length of 72 in. and a width of $22^{1}/_{2}$ inches. The total weight of the machine is approximately 1500 lb.

Similar assemblies have been constructed using Allis-Chalmers, Wylies Overland Jeep or Ford motors with either

PAGE *Welding* ELECTRODES



PAGE COATING HELPS YOU ON YOUR STAINLESS WELDING

Certainly it is important to you that **PAGE** developed a range of electrodes for welding stainless steel that is complete.

But don't overlook the important value to you of the **PAGE** coating on these electrodes—sufficiently heavy to provide the shield necessary to prevent oxidation; to provide the protection of easily removed slag that permits more cooling time; that eliminates surface checking, and that holds spatter loss to a minimum.

PAGE ALLEGHENY STAINLESS STEEL ELECTRODES provide the metal you want, help you get it where you want it and protect the job your men do. Ask your local **PAGE** Distributor.

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Monessen, Pa., Atlanta, Chicago, Denver, Los Angeles, New York, Pittsburgh, Portland, San Francisco

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ESSENTIAL PRODUCTS . . . TRU-LAY Aircraft, Automotive, and Industrial Controls, TRU-LOC Aircraft Terminals, AMERICAN CABLE Wire Rope, TRU-STOP Brakes, AMERICAN Chain, WEED Tire Chains, ACCO Malleable Castings, CAMPBELL Cutting Machines, FORD Hoists, Trolleys, HAZARD Wire Rope, Yacht Rigging, MANLEY Auto Service Equipment, OWEN Springs, PAGE Fence, Shaped Wire, Welding Wire, READING-PRATT & CADY Valves, READING Electric Steel Castings, WRIGHT Hoists, Cranes, Presses . . . *In Business for Your Safety*

Lincoln, or P and H generators. Welding machines with 200-, 300- or 400-amp. capacity generators can be furnished.

These portable welding machines are designed for locations where electric power is not available and particularly, due to their low center of gravity, where the welding work is to be done in rough terrain.

Special designs can be made to suit customer requirements.

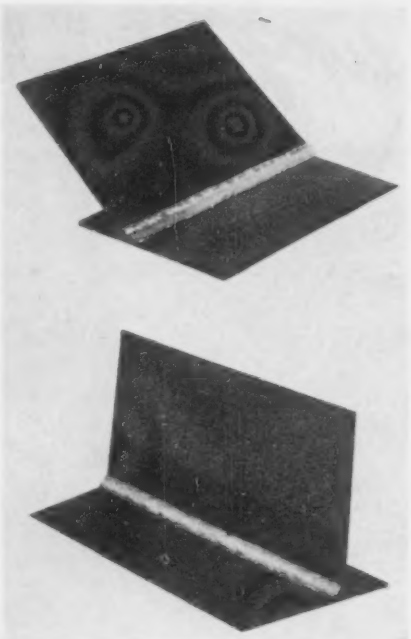
GENERAL-PURPOSE A.C.-D.C. ELECTRODE

A new general-purpose arc-welding electrode for welding mild steel in all positions, with either alternating or direct current, is announced by The Lincoln Electric Co., Cleveland, Ohio.

The new electrode, named "Fleetweld 37," is the most recent addition to the well-known "Fleetweld" group of Lincoln electrodes for welding mild and low-alloy steels.

"Fleetweld 37" was originally designed as an easy striking, unusually smooth operating electrode primarily for light gage material. Extensive use in production has also shown it to be a very fast operating electrode under all conditions.

A remarkable feature of the new electrode is that there is absolutely no slag interference when welding vertical down. This means excellent results are achieved in this position, the one in which greatest welding speeds on 8- to 16-gage steel are obtained.



(Top) Lap Joint Welded with "Fleetweld 37." (Bottom) Fillet or Tee Joint Welded with "Fleetweld 37"

The ability of "Fleetweld 37" to withstand higher currents, both alternating and direct, makes possible higher welding speeds than normal and its easy handling characteristics in all positions make it an ideal electrode for general-purpose work.

"Fleetweld 37" has unusual physical properties for this type of electrode. The physical properties of all-weld-metal specimens are as follows:

Tensile strength, 70,000 to 80,000 psi.
Yield strength, 60,000 to 68,000 psi.
Ductility (elongation in 2 in.), 18 to 25%

"Fleetweld 37" conforms to AMERICAN WELDING SOCIETY classifications for arc-welding electrodes E-6012, E-6013, E-7011 and E-7012.

The new electrode is available in the 1/8-, 5/32- and 3/16-in. sizes in 14-in. lengths and is packed in 50-lb. standard container.

INDUSTRIAL SAFETY GOGGLE

A rugged, new, all-plastic goggle for general industrial utility. One-piece lens is of shatterproof methacrylate that withstands heavy impact . . . is highly resistant to pitting caused by sparks. Curved plastic frame fits the face snugly but comfortably, shields the eyes from every angle. Unique construction permits easy replacement of low-cost lens. Sturdily made to give long, safe service and reinforced with high-brass clip at bridge. Nonfogging. In writing for samples and price, specify Model 7.

Available through your own jobber, or Watchemoket Optical Co., Inc., Providence 3, R. I.

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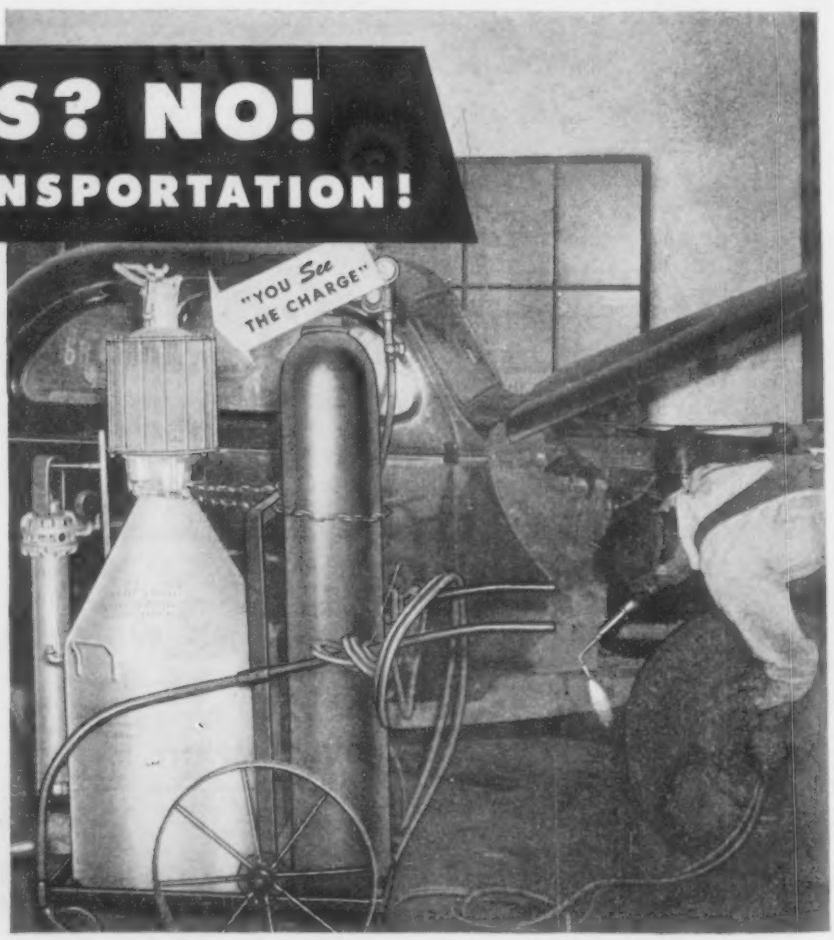
CRITICAL TRANSPORTATION!



● REMEMBER WHEN a lot of folks traded in their cars for new ones *every year?* And the venerable age of two or three winters automatically assigned the ole family bus to the *jalopy* class? But not so today. America's *newest* cars are now observing their *third* birthday. Jalopies? No — *critical transportation*—with native ingenuity and a welding torch to keep 'em rolling to and from the war plants. (And the welding torch performs more economically if hooked to a Sight Feed Acetylene Generator—famous source of purer, hotter acetylene gas at savings up to 75%.)

THE *Sight Feed* GENERATOR COMPANY

Sales: Richmond, Ind. Factory: W. Alexandria, O.

FOR BEST RESULTS On "Poor Fit-Up" Jobs

Use Raco 8 Shielded Arc Electrodes

Bridging wide gaps in poorly fitted joints is work just "made" for Raco 8's, because these Electrodes are versatile. They produce excellent multiple pass, high tensile medium ductility welds in all positions. Furthermore, though Raco 8 Electrodes give best results with direct current, straight polarity, satisfactory welds can be made with reverse polarity and with alternating current. Try Raco 8 Electrodes on *your* "Poor Fit-Ups." You'll be rewarded with faster, better production, lower costs.

Raco 8 Electrodes comply with all these specifications:

A.W.S.—A.S.T.M. Specification A233-42T, Type E-6012.

A.S.M.E. Boiler Code, Para. U-70.

American Bureau of Shipping, Grades H1G and B2G (A.C. or D.C.)

Dept. of Commerce, Bureau of Marine Inspection and Navigation.

★

Use Raco 82 Electrodes for building up worn parts and surfaces of medium-carbon steel. Welds are machineable.

The REID-AVERY COMPANY

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SECTION ACTIVITIES

BOSTON

At the November 8th dinner meeting of the Boston Section Henry DeM. Lucas of Handy & Harman gave an interesting illustrated talk on "Silver Alloy Brazing as Applied to War Production."

The December meeting held on the 13th was Navy night with an All-Navy program. As coffee speaker, Lt. Thurston G. Powell, M.C., U.S.N.R., spoke on the "Medical Aspects of Welding."

Lt.-Comdr. James A. Brown, U. S. Navy, spoke on "Construction of Destroyer Escort Vessels" and explained welding techniques involved in this construction.

A Navy film, "Pearl Harbor," was shown.

At January 10, 1944, meeting the coffee speaker was Major John R. Canavan, U. S. Army, who chose for his subject "Military Operations in the South Pacific." At the meeting proper, which started at 7:45 P.M., R. F. Helmkamp of the Air Reduction Sales Company spoke on "Recent Developments in Oxyacetylene Machine Cutting."

CHATTANOOGA

The December 17th meeting was started off with a dinner at which about 26 members and friends were present. After dinner the group convened in the Red Room of the Hotel Patten where a U. S. Army motion picture was presented by and through the courtesy of the WAC regiment stationed at Ft. Oglethorpe, Ga.

The principal speaker for the technical session was Bent Laune, Eastern Sales Manager of the Eutectic Welding Alloys Company, New York. He conducted a very interesting talk illustrated with slides and was ably assisted by his company's Field Service Engineer, John C. Thieme.

The Program Committee of the Chattanooga Section is ably headed by R. E. Lorentz, Jr., of Combustion Engineering Co., who has been successful in securing outstanding speakers.

CHICAGO

The Chicago Section, AMERICAN WELDING SOCIETY, held its December meeting December 17th. The speaker of the evening was Major S. C. Massari, Officer in Charge of the Engineering Unit of Tank Automotive Branch. Major Massari spoke on "Welding as Applied to the Manufacture of Ordnance Equipment." In an informal talk of a most constructive nature from a general welding standpoint Major Massari discussed the important role welding is playing in the production of ordnance equipment. Much of his discussion was devoted to the welding of M-4 tanks and the important part welding is playing in making these implements of war superior to those of the enemy. There followed a general discussion which included not only requests for information on welding but also regarding many phases of the war. These questions were ably answered by Major Massari when National Security was not involved.

At a meeting of the Board of Directors of the Chicago Section, AMERICAN WELDING SOCIETY, the resignation of H. J. Kircherer as Vice-Chairman of the Chicago Section was accepted because of pressing duties which made it impossible for Mr. Kircherer to continue to function as Vice-Chairman of the Section.

C. L. Pfeiffer, Western Electric Co., Chicago, a director of the Chicago Section was appointed to fill his unexpired term by the Board of Directors. The elevation of Mr. Pfeiffer to Vice-Chairman made it necessary to appoint a director to fill the vacancy resulting from Mr. Pfeiffer's appointment. E. P. Auler, Taylor Pip and Forge Works, Chicago, was appointed as a director.

CINCINNATI

A joint meeting of the American Society of Tool Engineers and the Cincinnati Section of the AMERICAN WELDING SOCIETY was held on January 11th at the Hotel Alms. W. W. Petry of the Cincinnati Milling Machine Co., spoke on the subject "Interesting Physical and Metallurgical Reactions in Welding."

CLEVELAND

The regular monthly meeting was held at the Cleveland Engineering Society on January 12th. Dr. Kent Van Horn spoke on the subject of "Radiographic Inspection of Welded Plates and Castings." The talk was devoted to the fundamentals of radiography and the degree of sensitivity that can be expected from this method under commercial X-ray laboratory conditions. Types of X-ray apparatus suitable for the examination of welded plates and pressure vessels were described. Radiographs of various type of defects that may occur in welds were shown to aid the description of the appearance on the radiograph of the defects that might occur in steel welds.

Dr. Van Horn was an instructor at Yale and, for the past fifteen years, has been a research metallurgist for the Aluminum Company of America.

Those who attended the dinner which preceded the meeting had an opportunity to hear the story of "The Big Inch Pipe Line" told by Technicolor sound pictures.

COLUMBUS

La Motte Grover, Structural Engineer, Air Reduction Sales Co., was the speaker at the January 14th meeting of the Columbus Section, which meeting was held at Battelle Memorial Institute. Mr. Grover's subject was on "Structural and Ship Welding."

CONNECTICUT

The December meeting of the Connecticut Section was held on the 9th at the Bridgeport General Electric Institute. R. W. Clark of the General Electric Co., spoke on the subject "Atomic Hydrogen Welding and Its Applications." A film "Atomic Hydrogen Welding" was also shown in connection with presentation of the paper.

DETROIT

The monthly meeting of the Detroit Section was held in conjunction with the Flint Division on January 7th in the Rackham Memorial Building, Detroit. The meeting was preceded by 45 minutes of delightful entertainment furnished by the Ford Mercury Rangers. Hayes Bennett of the Ford Motor Co. acted as master of ceremonies.

The meeting was in the nature of a Welding Spell Down. The Chrysler Corp., Ford Motor Co. and the Fisher Tank Division each had three experts on the stage. Questions from the audience were answered by the experts. The ovation rendered by the audience for the answers given were registered on an Applause Meter. There was insufficient time to submit all questions to the group, although the meeting was not closed until 10:30 P.M.

KANSAS CITY

The December meeting of the Kansas City Section of the AMERICAN WELDING SOCIETY was held Tuesday evening, December 14, 1943, at Fred Harvey's Pine Room.

The largest attendance of the year was present despite the fact that a heavy snow and zero weather tended to make all people want to stay near the home fire.

The speaker of the evening was W. J. Conley, Consulting Engineer, The Lincoln Electric Co., Cleveland, Ohio, on the subject, "Engineering Aspects of Arc-Welded Jigs and Fixtures."

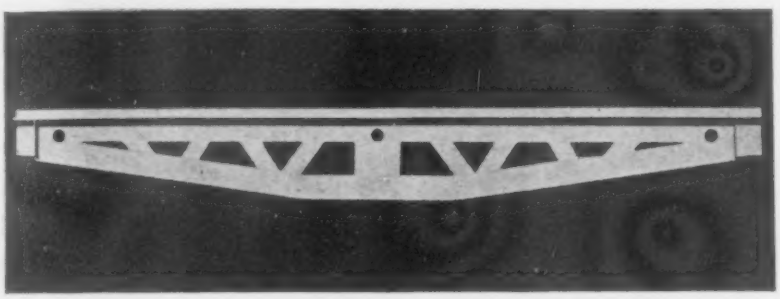
Mr. Conley's talk, supplemented with a great number of slides, was very interesting to the members and guests, since the subject was very apropos dealing with the tremendous saving which can be accomplished by means of jigs and fixtures and the positioning of parts to be welded. The speaker also covered the savings which can be made by using intelligent and careful design of welded structures in place of blindly following the old and antiquated concepts of design.

LOUISVILLE

A Silver Alloy Brazing Clinic, cosponsor: Handy & Harman, was held on

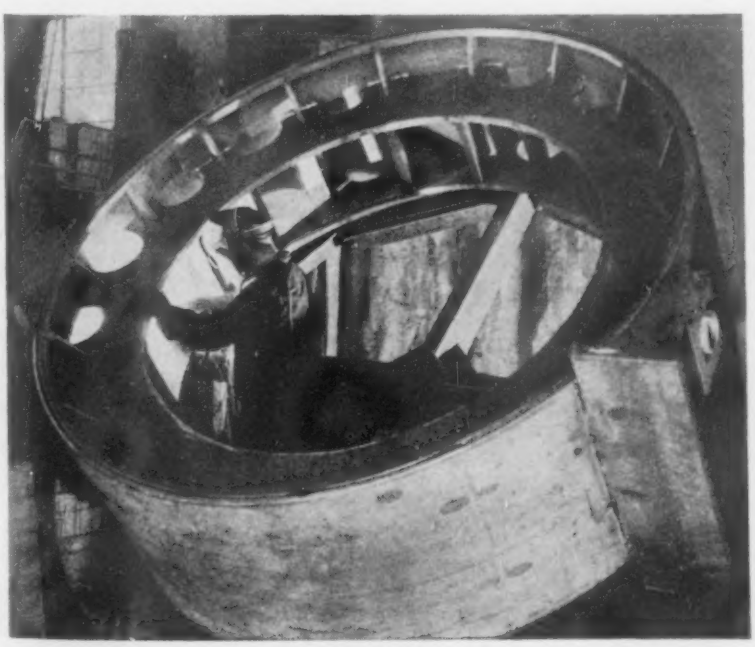
ARC WELDING HIGH LIGHTS

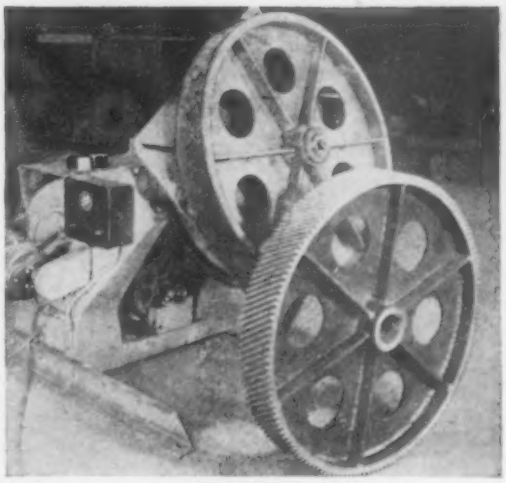
BETTER DELIVERIES of electrodes are the order of the day, thanks to the current higher output of manufacturers, and to the curtailment of certain parts of the war production program. The latest production figures reveal that almost 65% more mild steel, coated electrodes were produced in the first eleven months of 1943 than in the corresponding period the previous year. Deliveries now generally may be made in weeks instead of months; and certain types of electrodes can be shipped immediately. *However, fabricators should continue to order as far ahead as possible, as this enables electrode manufacturers to anticipate and meet the specific demands for various types.*



HATCH SHIFTING BEAM saves ten tons of steel per ship. Twenty feet long, weighing 1,125 pounds, these beams are produced in quantity by the Globe Company of Chicago. Welding is done in ten specially designed fixtures, each of which aligns and holds parts in position as they are welded. Quarter-inch reverse polarity rods are used for welding the lacings and gussets and $\frac{7}{32}$" Murex Type FHP for the intermittent fillet welds that attach the long plate to the top of each beam.

THE ELECTRIC MACHINERY MANUFACTURING COMPANY of Minneapolis, a leading designer and manufacturer of synchronous motors, reports that arc welding has taken the place of cast construction in pedestal bearings, stator frames, and bases. Welding approximately halves weight; produces greater rigidity and sturdiness; permits variations of design at small cost. Overall savings are estimated at more than 30%.





ARC WELDING IS A 50% TIME-SAVER as compared with casting in the fabrication of heavy gear blanks, according to the Ransome Concrete Machinery Company, Dunellen, New Jersey. Murex Types F and FHP "hot" rods used at high currents permit rapid deposition of weld metal and result in smooth, uniform welds of great strength.

SPHERICAL ANTI-SUBMARINE NET FLOATS by the thousands are built by Brown Steel Tank Co., Minneapolis. Each float is fabricated from six segments of 3/16 inch steel plate. Positioners are used. Welds are made from the outside, using $\frac{1}{4}$" Murex Fillex electrodes. These floats withstand salt water submergence tests to a depth of 250 feet.

MUREX

ARC WELDING ELECTRODES

•

METAL & THERMIT CORPORATION

120 Broadway, New York 5, N. Y.

ALBANY • CHICAGO • PITTSBURGH
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Specialists in welding for nearly forty years. Manufacturers of Murex Electrodes for arc welding, and of Thermit for repair and fabrication of heavy parts.

the afternoon and evening of December 20th in the Auditorium of Speed Scientific School, University of Louisville. "Silver Brazing and Its Application in Industry" was discussed and demonstrated at each session by M. C. Robbins, Manager of the Chicago Office, assisted by H. R. Cole, Brazing Engineer, both of Handy & Harman.

MILWAUKEE

Mayor John L. Bohn of the City of Milwaukee was the after-dinner speaker at the December 17th meeting of the Milwaukee Section. F. McGuire, Jr., Division Process Service Engineer, The Linde Air Products Co., Chicago, presented the welding address on "Use of Oxyacetylene Flame for Heat Treating." Mr. McGuire also discussed Flame Hardening, Flame Softening and Flame Straightening.

MOBILE

An Election of Officers and a General Get-together of the members was held on December 16th at the Lodge of the Gulf Fishing and Hunting Club on Dog River. The following officers were elected: *Chairman*, Reynolds T. Alonzo; *Vice-Chairman*, W. W. Tieman, *Secretary-Treasurer*, William E. Kelly; *Program Director*, Henry B. Tonsmeire; *Publicity Manager*, W. D. Baugh.

The following Membership Committee was also appointed: *Chairman*, John E. M. Enroth; Michael O. Collier; W. T. Sweetser.

It has also been decided to hold the 1944 meetings at the Admiral Semmees Hotel.

NEW JERSEY

The regular dinner preceded the December 21st meeting at the Essex House, Newark. Twenty-six attended the dinner. Seventy-six attended the meeting which was addressed by O. T. Barnett, of the Metal & Thermit Corp., who spoke on "Arc Welding Mild Steel Electrode Coatings." Mr. Barnett's presentation was very well received. Slides and a motion picture, entitled "Thermit Welding" were also shown in connection with the presentation of the paper.

NEW YORK

The New York Section held its regular monthly meeting on Monday, December 13th, at the Engineering Societies Building. Technical Chairman for the evening was A. N. Kugler, Air Reduction Co., New York.

Speaker for the evening was S. P. Orlando, Engineer, Seaboard Engineering Co., New York, who spoke on the subject "Jigging for Precision Welding." Mr. Orlando presented the paper originally prepared by J. W. Clerke of the Airplane Parts Division, Glidden-Buick Corp., who was unable to be present due to illness. The paper, which was accompanied by slides and models of jig assemblies, covered the design and construction of production line jigs and fixtures. Also discussed were jigging methods for downhand, tack and continuous gas and arc welding, as well as welding procedures, flame control, rod size, etc.

Two motion pictures were shown at the conclusion of Mr. Orlando's talk. The first, "Building a Bomber" was presented through the courtesy of the United States Government. The second picture "Building the Alcan Highway" was presented by the Firestone Tire and Rubber Co.

The evening opened with a half-hour question and answer period conducted by E. Vom Steeg, Jr., General Electric Co., N. J.

NORTHERN NEW YORK

The November 18th meeting was held at the Schenectady Y.W.C.A. A. M. Setapen, of Handy & Harman, spoke on "Brazing and the War Industries."

NORTHWEST

W. E. Whitehouse, Defoe Shipbuilding Co., Bay City, Mich., spoke on "Welding of Boats Upside Down" at the December 15th meeting held in the Men's Lounge, Coffman Memorial Union, U. of Minnesota.

Two technicolor sound films produced for the Metal & Thermit Corp. were also shown. One picture "Fabrication of Stern Frames by Thermit Welding" describes the welding procedure in building frames for C-2, Victory and Liberty ships. The other film was "Thermit Rail Welding in the Famous Moffat Tunnel." Questions were answered by Louis Vock, District Thermit Engineer.

OKLAHOMA CITY

The December Meeting of the Oklahoma City Section of the AMERICAN WELDING SOCIETY was held on December 16th, at 8:00 P.M. at the Biltmore Hotel. Our speaker for the occasion was W. J. Conley, Consulting Engineer, The Lincoln Electric Co., Cleveland, Ohio. He used slides along with his talk and very effectively covered his subject which was "Factors Affecting the Arc Welding of Steels Having Critical Hardenability." Mr. Conley covered in a very clear and concise manner his rational approach to problems concerning "Hard-to-Weld" alloy steels. He showed that if the proper consideration was given to certain basic factors, consistently good welds could be made in practically any weldable material. The familiarity with which Mr. Conley presented his subject showed beyond a doubt that much research and study had been given to his subject.

The January meeting of the Oklahoma City Section was held in Parlor "A," Biltmore Hotel, 8:00 P.M., on the 6th. A most excellent speaker for the occasion was G. N. Seiger, President and General Manager, SMS Corp., Detroit, Mich. His announced speech of "Resistance Welding," proved to be quite a drawing card, especially to those whose work was with that type of welding. Mr. Sieger proved to be a master of his subject and presented his material in such a manner that the audience was reluctant to allow him to stop, even though the hour was growing late. A lively discussion followed his talk, and as usually happens, amplified considerably the outline which formed the basis for his talk.

Mr. Sieger preceded his announced subject by a short discussion of AMERICAN WELDING SOCIETY subjects and activities, and judging from his remarks, he appears well chosen as National Chairman of the Membership Committee.

Due to the Chairman, M. G. Wicker, being absent because of business, H. N. Simms, Vice-Chairman presided.

PHILADELPHIA

The December meeting of the Philadelphia Section was held in the Philadelphia Electric Co. Auditorium, Monday, December 20, 1943, in conjunction with the American Society of Naval Architects and Marine Engineers.

About 250 persons were present to hear an excellent talk on Welding in Ship Construction, by Lyell Wilson of the American Bureau of Shipping. Mr. Wilson demonstrated that the recent failures have not been attributable to any single cause, but have been the result of many causes that have tended to exhibit their effects at the weakest point in the structure involved. He cautioned designers about making structures that will throw the load on reduced sections, that were never planned to take the full load

In the discussion, T. M. Jackson, Welding Engineer of Sun Shipbuilding and Dry Dock Company, stressed the importance of keeping to a regulated and predetermined welding sequence. C. A. Adams, consulting engineer for Edward G. Budd Manufacturing Co., told those present about the AMERICAN WELDING SOCIETY's and other plans for increased fundamental research work, to determine

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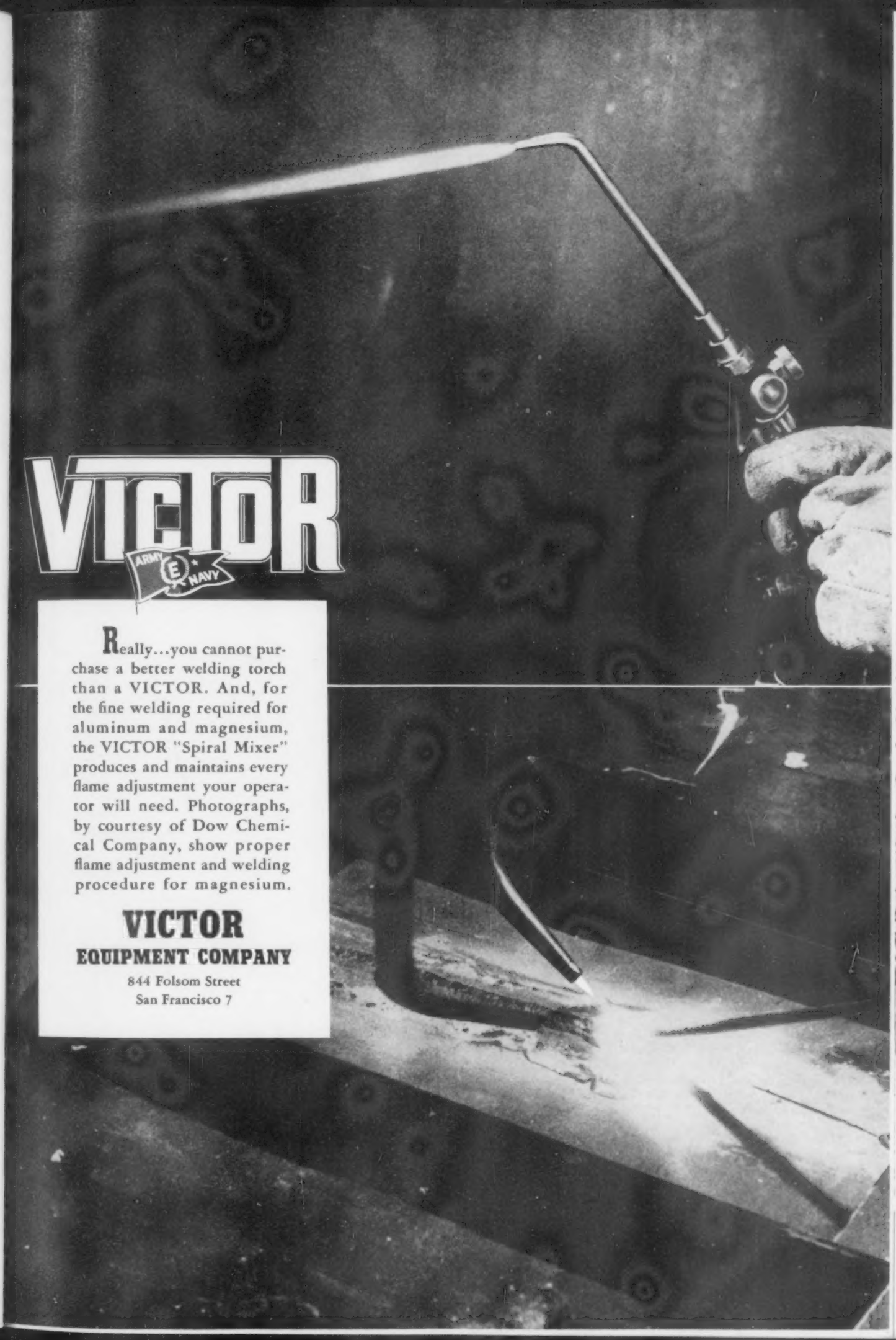

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the basic principles behind our difficulties. H. W. Pearce, Chairman of the Philadelphia Section, stated that we should make certain that we do good welding and then let the materials do the work the best it can under the working conditions. He stated that we should analyze our designs and make sure that every part was being used within the limit of its capacity to eliminate the possibility of developing conditions where a very small part does twice as much work as it was originally intended to do.

The speaker of the evening was introduced by E. H. Riggs, Chairman of the Philadelphia Section of American Society of Naval Architects and Marine Engineers.

ROCHESTER

Dinner preceded the January 6th meeting held at the University of Rochester. Eighteen attended the dinner. Sixty attended the meeting which followed. Paul W. James, The Lincoln Electric Co., spoke on "Welding Electrodes and Their Application."

SAN FRANCISCO

The October 29th meeting was held in the form of a discussion on Welding in the Railroads. Frank Longo, Junior Past-Chairman and General Boiler Inspector for the Southern Pacific Co. conducted the discussion. The second half of the meeting was devoted to the sound motion picture, narrated by Edwin C. Hill, "Full Speed Ahead."

The November 26th meeting was addressed by Harold N. Ewertz, President, Arcos Corp., Philadelphia, who presented some interesting facts about Stainless Steel Electrodes.

The Annual Stag Entertainment Meeting was held on December 17th at the Athens Athletic Club, Oakland. A ticket of admission which entitled each member to bring a guest was mailed to the members in advance. A good time was had by all.

SYRACUSE

The regular monthly meeting was held on January 13th at the Museum of Fine Arts. Mario Sciaky of Sciaky Bros., Chicago, talked on Resistance Welding with special reference to new methods of Spot Welding developed for the Aircraft Industry.

WASHINGTON, D. C.

The annual joint meeting of the Washington Chapter of the A.S.M. and A.W.S. was held early in December at the Garden House of the Hotel Dodge. Chairman C. E. Jackson of the A.S.M. introduced the local Welding Society chairman, H. L. Ingram, to a capacity crowd that had turned out to hear LaMotte Grover, welding engineer of Air Reduction Sales Co. talk about "Procedure Control and Details for Welded Ships and Other Large Structures."

The subject was more than timely, particularly since the failure of several welded cargo ships has highlighted the need for more careful study of large welded structures, with emphasis on stresses induced by welding.

Mr. Grover has been associated with steel construction and design work for 23 years and his work at the Air Reduction Co. has brought him in close touch with problems of the shipbuilding industry. He is active on the committee which is advising the Maritime Commission on thermal stresses and his wide experience afforded an interesting evening.

By way of introduction the speaker described the status of welding in shipyards at the present time. His paper was printed in full in the April 1943 WELDING JOURNAL. Welding gained favor in ship construction when it was found that there was a lack of riveters and technical difficulties and inconveniences persisted with the combination of welding and riveting. It was subsequently found easier to train welders than riveters. Britain's advance in welding for ship construction was slower than in the U. S. due to congested yards and unwillingness to school welders and change over. But welding is advancing now since preference of individual workers are along these lines. Present shipbuilding yards are working far beyond their capacity under very trying conditions in this "war of tonnage" under abnormal conditions, and, Mr. Grover emphasized, the program would not have been possible had it not been for welding.

WESTERN MASSACHUSETTS

The December meeting held in the Holyoke Trade School on the 22nd was addressed by Harold Wrigley, Supervisor of Jigs and Fixtures at the Worthington Pump and Machinery Corp. Using an actual example of a jig making project, Mr. Wrigley discussed various aspects of jigs and fixtures for production welding including design, materials, shrinkage allowances and clamping devices. After an interesting discussion period, a 55-minute talking picture called "Prelude to War," recently released by the OWI, gave an introspective view of how the "isms" got their start.

WICHITA

W. J. Conley, Consulting Engineer, Lincoln Electric Co., spoke on Factors Affecting Arc Welding of Steels having critical hardenability, at the December 15th meeting held in the Empire Room, Allis Hotel.

The January meeting on the 6th was also held at the Allis Hotel. Twelve members and guests were present for the informal dinner which preceded the meeting. G. N. Sieger of the SMS Corp., Detroit, gave a very entertaining and interesting lecture and sketch on the principles of resistance welding. About 80 members and guests were present at the meeting.

YORK-CENTRAL PENNSYLVANIA

The November meeting hit a record high in interest and attendance. One hundred members and guests were present. An item of special interest was the lecture on Thermit Welding by J. H. Deppeler, Chief Engineer of Thermit Welding Corp., New York, and a former president of the AMERICAN WELDING SOCIETY. In addition to his enlightening speech, Mr. Deppeler ran the 25-minute colored sound picture which was shown at the Chicago Convention. This was a late thermit picture of work done in the Marine Field, disclosing the mysteries of Thermit Welding.

Another interesting feature was the welding exhibit furnished through the courtesy of York Safe & Lock Company, showing the simplicity and speed with which a part can be assembled for welding.

A high light of the evening was the turnout of York Corp.'s welding supervisor with twelve of his beautiful lady welders. Of the four new members reported by the committee, one was a woman.

The December meeting which was held on the 8th in the Engineering Societies Building, was attended by members and guests. C. N. Ring, Field Engineer Magnaflux Corp. of New York, spoke on "Magnetic Particle Inspection." Mr. Ring showed a number of slides that covered both large and small welds.

The doors opened at 7:30 o'clock in order that those attending might view an exhibit furnished through the courtesy of the York Corp., of a partly fabricated condenser made especially for the Navy. The condenser was only partly fabricated to permit examination and to show the engineering which was employed to make this construction possible for welding.

Plans are now being made for a York-Central Section night to be known as York Night. This meeting is planned for the purpose of having all industries in this section who are doing fabricating by welding to make an exhibit. The showing of welding exhibits at the meetings seems to have the effect of attracting old and new members to the meetings. This policy of having an exhibit with every meeting will be followed out in the future.

Employment Service Bulletin

SERVICES AVAILABLE

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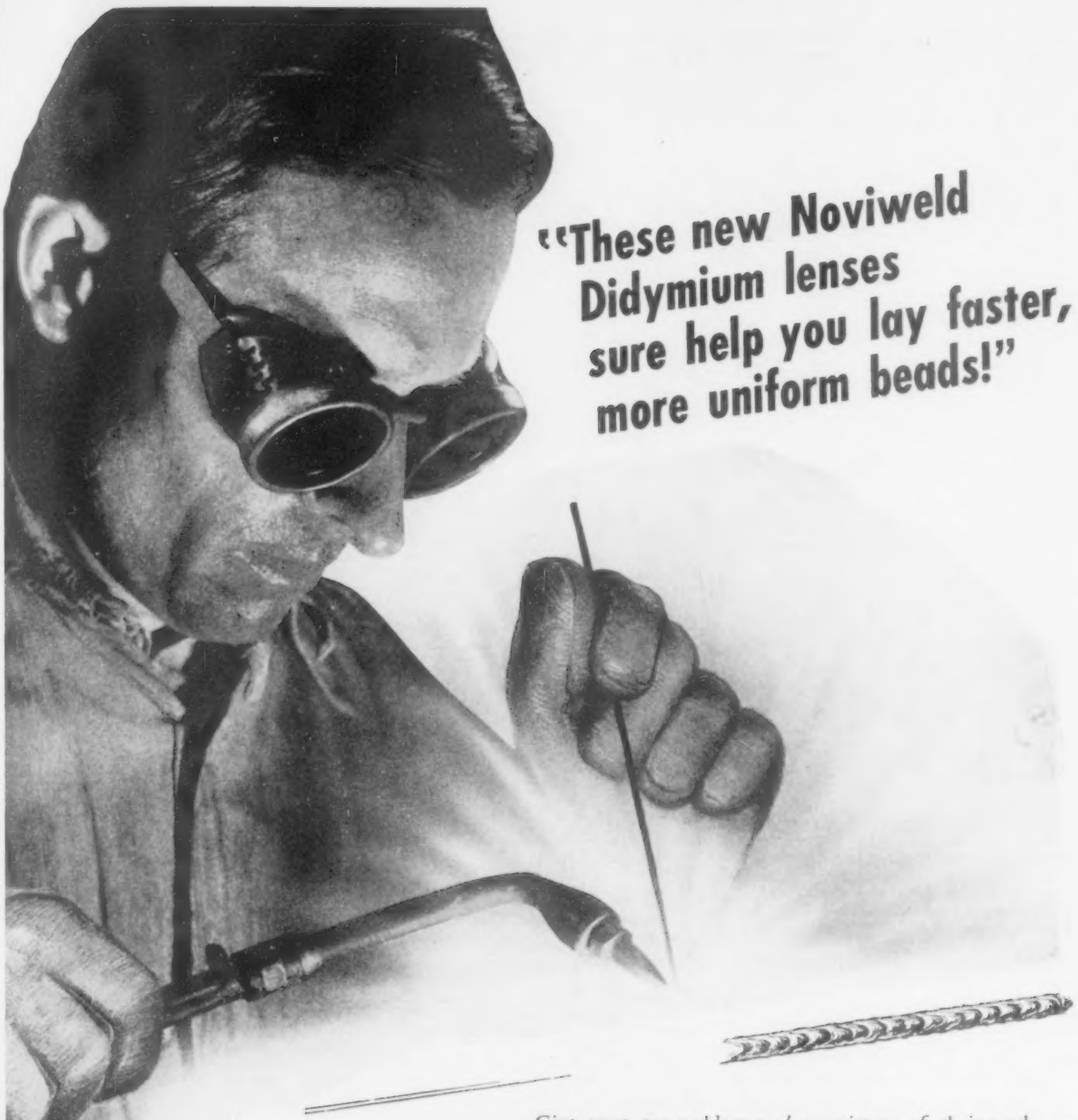
A-467. Man, aged 40, trustworthy with excellent qualifications covering 19 years' experience in shop supervision, metallurgy, welding, inspection of materials, pressure vessels and related equipment for oil refineries and chemical concerns. Wants position on Pacific Coast as Materials Engineer or General Inspector for Eastern concern. Will furnish detailed information on request.

A-468. Physical Metallurgist, age 28, Sc.D. Interested in Research and Development, particularly in problems relat-



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POSITIONS VACANT

V-132. Electrical Engineer for development work on arc-welding equipment. Familiarity with Underwriters Laboratories' requirements preferred.

V-133. Welding Engineer or Production Executive responsible for arc welding, now employed on War Production, not selling. Correspondence is invited with men who wish to produce outstanding results and also meet their own particular problems of employment after the war. Must be American citizen with excellent background of experience and must expect to continue welding engineering or production work. Strictly confidential.

V-134. Manager, Welding Department at shipyard employing about fifteen hundred people. Welding Department consisting of approximately two hundred. Man should be able to get along well with men. Should be thoroughly trained, schooled in all latest procedures. Good opportunity for now and postwar.

V-135. Development Engineer. Experienced in arc welding electrode coating development. Chemical, metallurgical or ceramic training desired.

List of New Members

December 1 to December 31, 1943

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Post, W. A. (B), 613 N. 9th St., Birmingham, Ala.

BOSTON

Anzmann, Irving N. (C), 12 Cumberland Ave., Portland, Me.
Bowler, Albert E. (C), 270 Highland Ave., So. Portland, Me.
Cloutier, Raymond J. (B), 311 No. Washington St., No. Attleboro, Mass.
Cota, J. Arthur (C), 272 Prov. Rd., Farnumsville, Mass.
Edgerton, Frank W. (B), Austin Hastings Co., Inc., 226 Binney St., Cambridge, Mass.
Grant, Joseph L. (C), 111 Washington St., Biddeford, Me.
Mahoney, John J. (C), 11 S. Hobart St., Brighton, Mass.
Ovaska, Ernest (C), 400 Cushing St., Hingham, Mass.
Russell, James G. (B), 209 Edge Hill Rd., Milton, Mass.
Watson, Laurel R. (C), 154 Cleaves St., Biddeford, Me.

CANADA

Brace, G. A. (B), Ferranti Electric Ltd., Mount Dennis, Toronto 9, Ontario, Canada.
Caldwell, Frederic Clifford (C), Ferranti Electric Ltd., Mount Dennis, Toronto 9 Ontario, Canada.
Chipperfield, John William (B), 26 Lessard Ave., Toronto 9, Ontario, Canada.
Cooper, Ashton B. (B), Ferranti Electric Ltd., Mount Dennis, Toronto 9, Ontario, Canada.
Dube, Albert (C), 180 Commercial St., Levis, P. Q., Canada.
Ellis, Harry W. G. (B), 33 Mount Royal Ave., Toronto, Ontario, Canada.
Osborne, Harold R. (B), Ferranti Electric Ltd., Mount Dennis, Toronto 9, Ontario, Canada.
Thomson, Dr. John M. (B), Ferranti Electric Ltd., Mount Dennis, Toronto 9, Ontario, Canada.

CHATTANOOGA

Dugger, J. W. (C), P. O. Box 749, Chattanooga 1, Tenn.
Edwards, William H. (C), Combustion Engrg. Co., 1032 West Main St., Chattanooga, Tenn.

CHICAGO

Briehl, N. J. (B), 321 So. Spring Ave., La Grange, Ill.
Candlin, J. E., Jr. (B), Pullman-Standard Car Mfg. Co., 10909 Cottage Grove Ave., Chicago, Ill.
Culver, Merritt J. (C), 30 Woodside Rd., Riverside, Ill.
Mazurek, Stanley, Jr. (C), 9 So. Clinton St., Chicago, Ill.
Slampak, Joseph A. (C), 435 West 65th Pl., Chicago, Ill.
Slazyk, Stanley M. J. (C), 1702 West 15th St., Cicero, Ill.

CINCINNATI

Campbell, H. F. (B), National Cylinder Gas Co., 4620 Este Ave., Cincinnati, Ohio.
Crabbe, J. S. (B), National Cylinder Gas Co., 4620 Este Ave., Cincinnati, Ohio.
Neil, H. W. (B), National Cylinder Gas Co., 4620 Este Ave., Cincinnati, Ohio.

CLEVELAND

Baughman, R. N. (B), Magnaflux Corp., 1920 Euclid Ave., Cleveland 15, Ohio.
Burnett, Robert (C), 1403 East 221st St., Euclid 17, Ohio.
Cowles, Walter C. (C), 60 Buckingham Rd., Rocky River, Ohio.
Mc Bride, Harry E. (C), 130 E. 364th St., Willoughby, Ohio.
Medas, George (C), 2916 Erin Ave., Cleveland, Ohio.

COLUMBUS

Welsh, Clarence R. (B), 1750 Demorest Rd., Grove City, Ohio.

DETROIT

Andrews, William (C), 8549 Central Ave., Detroit, Mich.
Gilbert, J. J. (B), Whitehead & Kales Co., 58 Haltiner St., Detroit, Mich.
Huedshman, Paul (B), Whitehead & Kales Co., 58 Haltiner St., Detroit, Mich.
Johnson, Thomas (C), Whitehead & Kales Co., 58 Haltiner St., Detroit, Mich.
Millard, Fred (C), Plymouth Flame Hardening Co., Plymouth, Mich.
Schoefield, F. (B), Whitehead & Kales Co., 58 Haltiner St., Detroit, Mich.
Schultz, William (C), 11836 Sheridan Ave., Dearborn, Mich.
Shoup, Harold R. (B), 2053 Oakdale, Detroit, Mich.
Warner, Richard M. (B), Genesee Welding Supply, 2301 N. Franklin Ave., Flint, Mich.
Whitsel, Roy (B), Whitehead & Kales Co., 58 Haltiner St., Detroit, Mich.

HAWAII

Auerback, Kelly Donald (C), Hawaiian Gas Products, Ltd., P. O. Box 2454, Honolulu, T. H.
Johnson, Leonard (C), Hawaiian Gas Products, Ltd., P. O. Box 2454, Honolulu, T. H.
Warner, David (C), Hawaiian Gas Products, Ltd., P. O. Box 2454, Honolulu, T. H.
Wysard, Paul (C), Hawaiian Gas Products, Ltd., P. O. Box 2454, Honolulu, T. H.

INDIANA

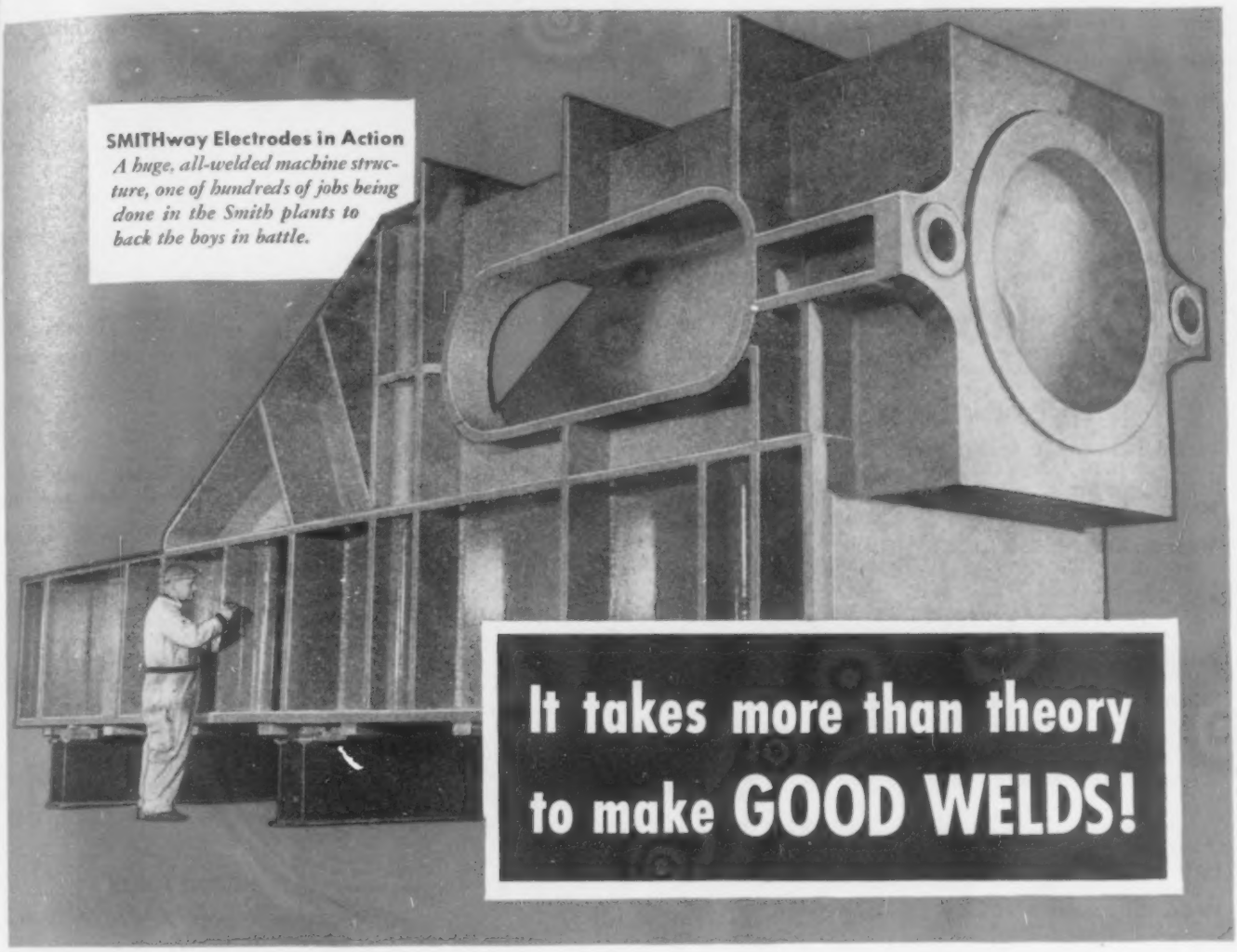
Benton, Floyd (C), New Harmony, Ind.
Hopper, J. D. (C), P. O. Box 936, Anderson, Ind.
McGahey, W. E. (B), 1011 Old 1st Bank Bldg., Fort Wayne 2, Ind.
Searle, Sam H. (C), 728 W. 7th St., Anderson, Ind.
Zahn, Otto C. (C), 1315 S. Washington St., Kokomo, Ind.

LEHIGH VALLEY

Morgan, Oliver J. (B), 114 Analomink St., E. Stroudsburg, Pa.

LOS ANGELES

Cook, L. J. (C), Waldrip Eng., Co., 11810 Center St., Hollydale, Calif.
Garibay, Joseph (C), 1517 Colegrove Ave., Montebello, Calif.
Grover, Willard E. (C), Apex Steel Corp., P. O. Box 550, Metro. Sta., Los Angeles, Calif.
Henry, Elmer E. (C), 143 Tivoli Dr., Long Beach 3, Calif.
Hodge, George B. (C), Waldrip Eng. Co., 11810 Center St., Hollydale, Calif.
Isley, P. R. (C), 617 East 73rd St., Los Angeles, Calif.
Jennings, Ernest E. (B), Rheem Mfg. Co., 4361 Firestone Blvd., Southgate, Calif.
Keen, David W. (C), 1435 W. 50th St., Los Angeles, Calif.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LOUISVILLE

Layfield, M. B. (C), American Bureau of Shipping, 1501 Ky. Home Life Bldg., Louisville, Ky.
Murphy, E. M. (B), Marine Electric Co., 110 S. First St., Louisville, Ky.
Wagner, Kenneth Lee (C), 1843 Grand Ave., Louisville, Ky.

MARYLAND

Barrett, Louis (C), 2907 Alden Rd., Parkville 14, Md.
Schafer, Philip E. (B), Philip E. Schafer Testing Lab., 1200 E. 20th St., Baltimore, Md.
Schnitker, Frederick F. Jr. (C), 1665 Davley Ave., Baltimore, Md.

MILWAUKEE

Lilly, William C. (C), 3535 S. 57th St., Milwaukee 14, Wis.
Prodoehl, Clemens F. (C), 1741 So. 2nd St., Milwaukee 4, Wis.

MOBILE

Gray, Curtis V. (B), 257 Westwood Ave., Mobile, Ala.
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McDonald, Robert E. (B), Navco, Ala.
Murdoch, Lt. Comm. Robert (C), 3738 Cedar Ave., Spring Hill, Ala.
Robertson, Sanford R. (B), Box 1117, Chickasaw, Ala.
Sweetser, W. T. (B), 318 Fourth St., Chickasaw, Ala.
Wynn, Thos. O. (B), 215 Fourth St., Chickasaw, Ala.

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Borden, P. H. (C), Seaford, N. Y.
Lewis, Robert B. (C), Room 810, 30 Church St., New York, N. Y.
Lodestro, Alfred (C), Grumman Aircraft Engrg. Corp., Welding Engrg. Dept. Plant 2, Bethpage, L. I., N. Y.
Nicholls, Maurice (B), Kaiser Company, Inc., 30 Church St., New York, N. Y.
Posner, Mitchell (B), 144-40—75th Ave., Flushing, N. Y.
Schaeffer, Raymond A. (C), 83-15—242 St., Bellerose, L. I.

NORTHERN NEW YORK

Rogers, Geo. L. (B), 119 McClellan St., Schenectady 4, N. Y.

NORTHWEST

Conroy, Francis P. (C), 1036 N. E. Gould St., Minneapolis, Minn.
Holden, Edwin W. (C), 5353 No. Dupont, Minneapolis, Minn.
Schleuder, Russell H. (C), Electric Mach. Mfg., Co. "R" Div., 821-2nd Ave., S. E., Minneapolis, Minn.

OMAHA

Wade, Duane H. (B), Box 87, Ralston, Neb.

PEORIA

Cunningham, John S. (C), Meyer Furnace Co., 1300 S. Washington, Peoria, Ill.

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Casper, Vincent (C), 3219 Tilton St., Philadelphia 34, Pa.
Crowthers, Wm. F. (C), 74 Oxford Ave., Gloucester Hgts., N. J.
Hayward, August C. (C), Glenn Ave., Box 221, Blackwood, N. J.
Kingsbury, S. S. (C), Bendix Aviation Corp., 4700 Wissahicken Ave., Philadelphia 44, Pa.
Reale, Salvatore (C), 7352 Claridge St., Philadelphia, Pa.
Stuffer, William S. (C), 7732 Rudderow Ave., Merchantville, N. J.
Stumpf, Harry C. (C), University of Delaware, Newark, Del.
Watkins, Richard G. (C), 5 Poplar Ave., Kirkwood, N. J.
West, Woodrow W. (C), Pennsylvania Crusher Co., 17th Fl., Liberty Trust Bldg., Philadelphia 7, Pa.

PITTSBURGH

Fritsche, M. H. (C), Brandt School Rd., R. D. 1, Wexford, Pa.
Mowrey, Rowland (C), 837 Vermont Ave., Glassport, Pa.
Smith, George A. (B), Pennsylvania Transformer Co., 808 Ridge Ave., N. S. Pittsburgh, Pa.

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Barrett, E. R. (B), A. O. Smith Corp., 414 Vance Bldg., Seattle, Wash.
Brannin, Irving W. (C), 925 Federal Ave., Seattle 2, Wash.
Davis, Clifford G. (C), 2541—15th Ave., So., Seattle, Wash.
Dow, Wilbur E. (C), P. O. Box 3387, Seattle, Wash.
Ferch, Ray A. (C), 5129 Orchard St., Seattle, Wash.
Hamill, George B. (B), Seattle-Tacoma Shipbldg. Corp., Welding Dept., Tacoma, Wash.
Keye, Vincent (C), Seattle-Tacoma Shipbldg. Corp., Seattle, Wash.
Gorde, E. J. (C), 4119 E. Blaine, Seattle 2, Wash.
Matthews, Stewart (C), Northern Gas Co., 9439 E. Marginal Way, Seattle, Wash.
Morris, Joe L. (B), Route 8, Box 379, Tacoma, Wash.
Patten, Ben, L. (C), 1027—9th Ave., S. W., Puyallup, Wash.
Richardson, Jackson C. (C), 5203—15th Ave., N. E., Seattle, Wash.
Robison, Merl (B), 611 North Wash. St., Tacoma 6, Wash.
Shectel, F. M. (B), 1031 East 44th, Tacoma 4, Wash.
Stubbs, Helmer (C), 7100—1st Ave., S. Seattle 6, Wash.
Thibeau, Dewey R. (C), 9275—51st Ave., South, Seattle, Wash.
Ward, Jack B. (B), Puget Sound Sheet Metal Works, 3631 E. Marginal Way, Seattle, Wash.
Wilder, Charles W. (B), Route 7, Box 479, Tacoma, Wash.
Woobank, Ben F. (C), 3907 West Hinds St., Seattle, Wash.

ST. LOUIS

Morrison, Lester H. (B), 1217 Bayard Ave., St. Louis, Mo.

SAN FRANCISCO

Egan, Charles P. (B), 2720 Humboldt Ave., Oakland, Calif.
Horner, Amos A. (B), Rt. 2, 101 D, Stockton, Calif.

SOUTH TEXAS

Middleton, Charles N. (C), P. O. Box 1031, Houston 1, Tex.

SYRACUSE

Bell, Myron (C), 324 Boston Rd., R. D. 2, East Syracuse, N. Y.
Blackwell, F. O., Jr. (C), 111 Rugby Rd., Syracuse, N. Y.
Breckheimer, Otto (C), 1407 Erie Blvd. East, Syracuse, N. Y.
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Davis, Ernest (C), 232 Edgemont Dr. Syracuse 3, N. Y.
Drumm, Thomas L. (C), 50 Hawley St., Oswego, N. Y.
Holton, John W. (C), Carrier Corp., So. Geddes St., Syracuse, N. Y.
Johanson, H. D. (C), 112 Oxford St., Syracuse, N. Y.
Kagi, Albert (C), 206 Briarcliffe Rd., East Syracuse, N. Y.
Lawrence, Warren H. (C), Central New York Power Corp., 300 Erie Blvd. West, Syracuse, N. Y.
Leneker, Raymond V. (C), 1019 Tyson Pl., Syracuse 6, N. Y.
Long, Robert C. (C), 615 James St., Syracuse, N. Y.
MacQueen, Charles E. (C), 408 Washington St., Watertown, N. Y.
Makey, Roy (C), R. F. D. 1, Liverpool, N. Y.
Marshall, Paul (C), R. F. D. 1, Liverpool, N. Y.
McNeil, Hector (C), 175 Nichols Ave., Syracuse, N. Y.
Meyers, Herman (C), 120 First North St., Syracuse 8, N. Y.
Miller, Harry (C), 104 Watson Rd., North Syracuse, N. Y.
Reed, Jesse E. (C), 105 Comstock Ave., Syracuse 10, N. Y

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W-72

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. . . for metallic-arc, carbon-arc, or gas welding

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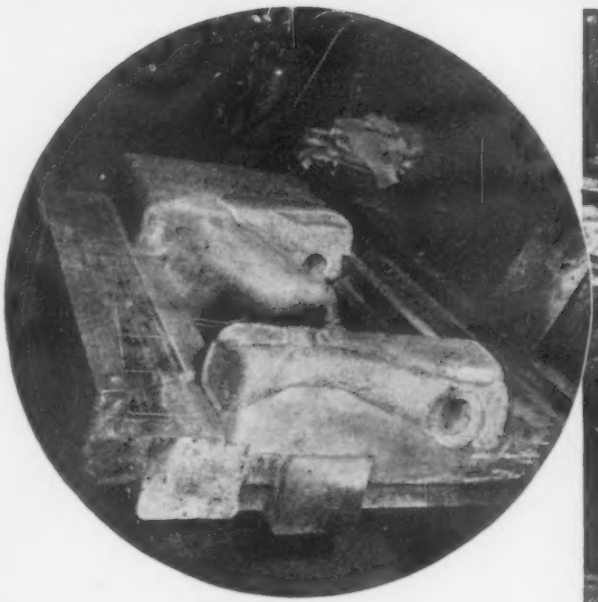
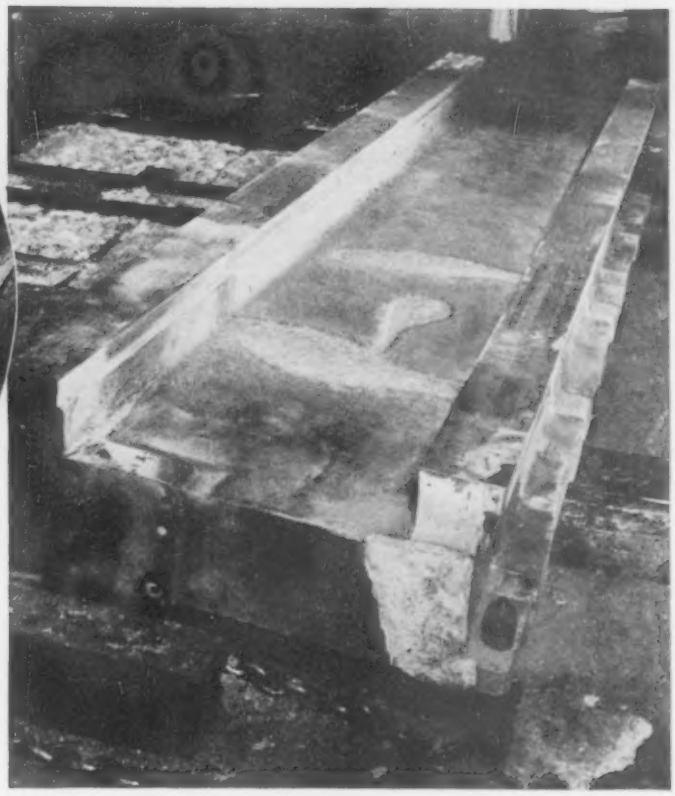
Chalk up *ANOTHER PRODUCTION VICTORY* for Bronze Repair Welding



Above: 3,000-pound saddle of milling machine reclaimed by Bronze Welding.



Right: Severed ribs in this base were welded as well as part of the bed.

A MILLING MACHINE was being moved to an important new war production job when the chain supporting it broke. Crashing to the floor, the machine was badly damaged. A long, costly production delay threatened until a new one could be obtained.

Then bronze welding came into the picture. Using this time-proved repair process, both the 15-ft. long base, weighing approximately 19,000 pounds, and the 3,000-pound saddle were quickly repaired by the Super Arc Welding Company, Detroit, Mich. 850 pounds of ⅜" Tobin Bronze* Welding Rod put the machine back on the job in a week.

For speedy repair welding of cast iron, steel, malleable iron and copper, don't overlook the advantages of such rods as Tobin Bronze and Anaconda 997 Low Fuming. Complete information on these and other Anaconda Welding Rods is contained in Publication B-13. Copy on request.

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Waldo, Arthur W. (from C to B), 4000 Hillman St., Youngstown, Ohio.

BENDING MACHINE SPEEDS PRODUCTION OF GEAR CASES FOR VICTORY SHIPS

A right-angle structure of steel can be made by standing a flat plate on another flat plate and welding the junction. It can also be made by bending a flat plate into a right angle. The bending method was adopted in production of gear cases for 226 new Victory ships, according to Westinghouse engineers. It has eliminated 50 miles of welding from the standard 8500-hp. gear case. In addition, it has saved 180,000 man-hours of skilled welders' time and 360,000 lb. of welding rod steel—a critical material.

Fig. 1—Bending Metal Plates Into Right-Angle Shapes to Make Gear Cases for Victory Ships. Westinghouse Engineers Discarded the Old Method of Welding Flat Plates Together, Piece by Piece, in Order to Speed Production and Save Man-hours

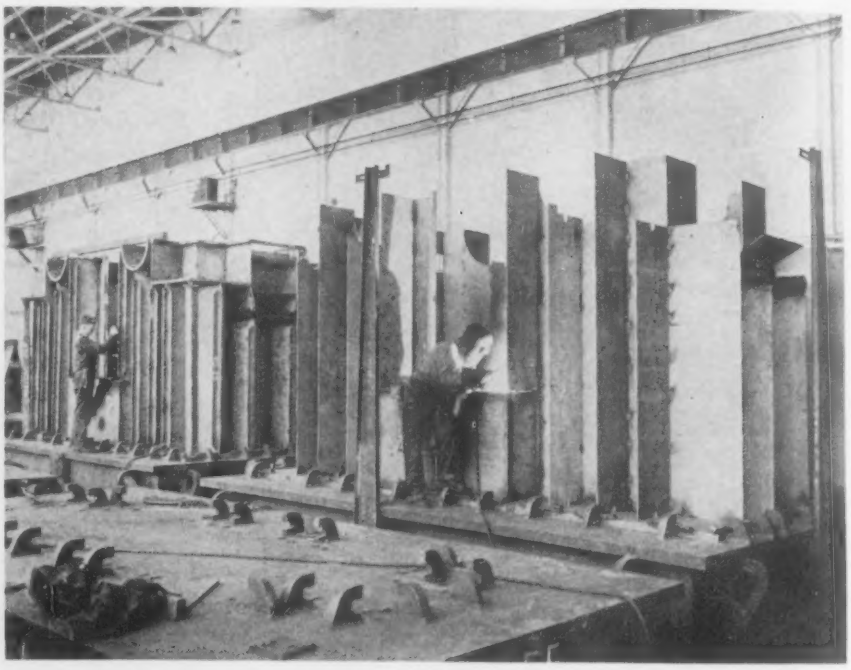


Fig. 2—Old Method for Building Gear Cases for Ship Propulsion Drives. Flat Plates Are Welded, Piece by Piece, from the Ground Up

Housings for big double-reduction gear drives for cargo vessels are complicated structures. They enclose and support the rotating elements, the heaviest of which is the second-reduction (bull) gear, measuring over 9 ft. in diameter. Gear cases must be stiff enough to maintain accurate alignment of pinion and gear wheel bearings for the five rotating elements. Forces exerted on these bearings at full speed are extremely heavy. Heretofore, these housings have been built up of flat iron plates, joined by means of seam welding. Victory ship designs utilize a bending machine (to the greatest degree possible) in forming the heavy steel plate into right angles. The new process not only saves man-hours and material but also provides somewhat greater stiffness. Previously, gear cases were built—one piece at a time—from the ground up. The new case can be built as seven distinct subassemblies—four for the base and three for the cover. The final step puts all seven together to make one unit. More rapid assembly, position for down-hand welding, are a few of the advantages attributed to the new shop procedure.

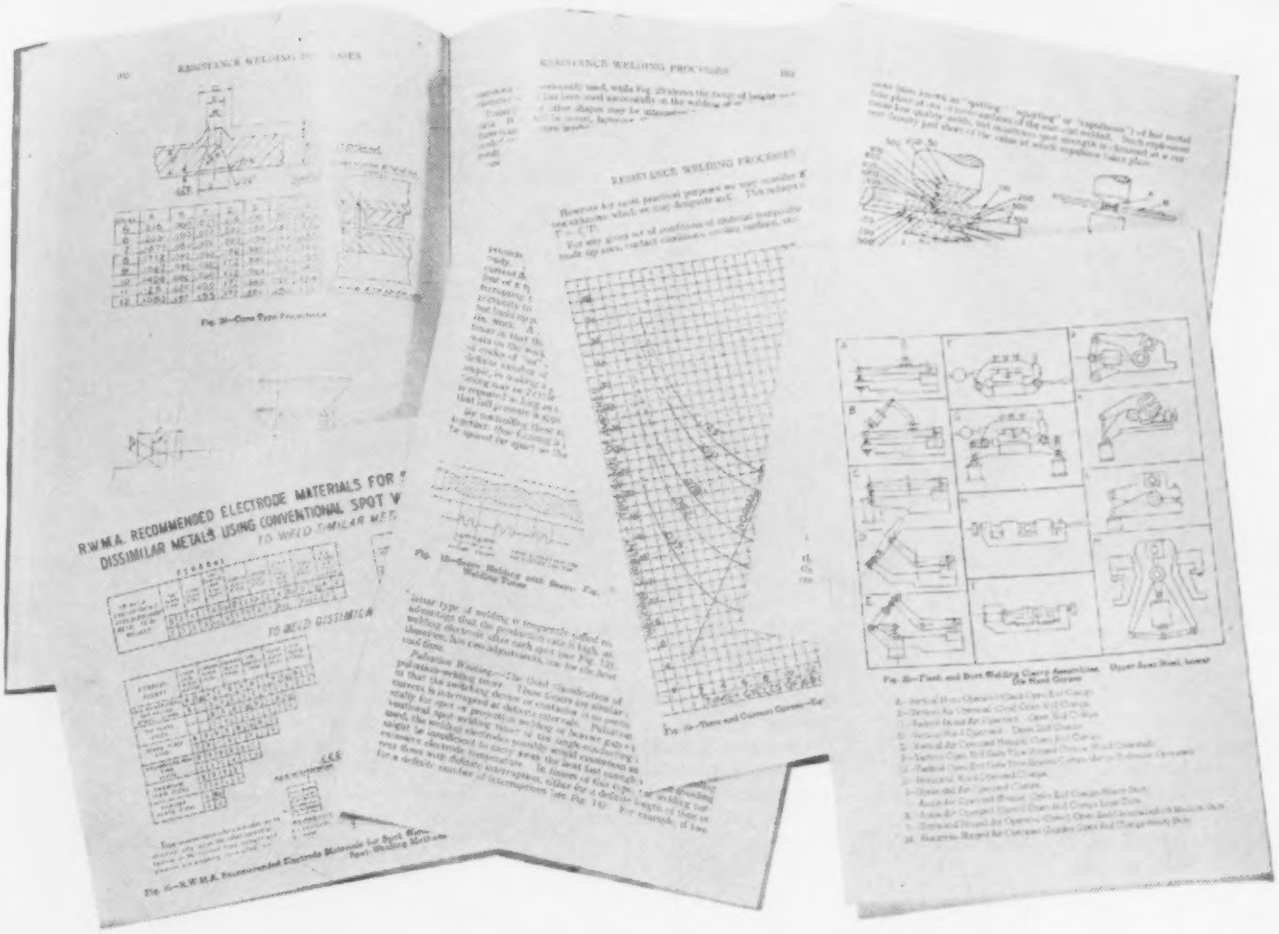
C. E. MACQUIGG HONORED

Charles Ellison MacQuigg, Dean of Engineering at Ohio State University was given the James Turner Morehead Medal of the International Acetylene Association at a dinner in his honor on Monday, January 24th, at the Union League Club, for "advancing the oxyacetylene processes through metallurgical research, and for leadership in welding engineering education."

The Morehead Medal is awarded annually by the International Acetylene Association in recognition of outstanding work in the acetylene industry, or for advancements in the production or use of calcium carbide. The medal is awarded in honor of the late James Turner Morehead, who sponsored the experiments which lead to the discovery, in 1892, of the modern electric-furnace method of producing calcium carbide, from which the acetylene industry has sprung.

In addition to his duties as Dean of Engineering at Ohio State, Mr. MacQuigg is also head of the Engineering Experiment Station; Director of the Ohio State University Research Foundation; member of the War Metallurgy Committee of the National Academy of Sciences; chairman of the Executive Committee of the Society for the Promotion of Engineering Education; Regional Director of the War Manpower Commission, Engineering Science and Management War Training Division; and director and chairman of the Executive Committee of the Orton Foundation.

During over thirty years in numerous



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Dean C. E. MacQuigg

types of metallurgical activities, Mr. MacQuigg has had a part in extensive research and development work on welds and materials for welding. He was long the guiding force of the Tests and Specifications Committee of the Compressed Gas Manufacturers' Association in the testing and development of cylinders for transportation of oxygen, acetylene and other compressed gases. Pioneer work under his direction, specifically in developing high-strength steel, bronze and stainless steel rods for oxyacetylene welding, has served as a foundation for many recent researches in this field.

In engineering education, Mr. MacQuigg holds an equally prominent place. Shortly after accepting his present position, he was instrumental in developing and establishing at Ohio State University the first, and still the only, complete four-year curriculum in welding engineering, leading to a baccalaureate degree in this subject. The success of this program has been followed by a growing interest and the later encouragement and establishment of many courses in welding engineering at other universities.

Prior to his appointment as Dean of the College of Engineering at Ohio State University in 1938, Mr. MacQuigg was manager of Union Carbide and Carbon Research Laboratories, Inc. Before beginning his services with that corporation in 1919, he was for five years head of the Department of Metallurgy at Pennsylvania State College.

Mr. MacQuigg is a member of Tau Beta Pi, honorary engineering fraternity and of Sigma Xi, honorary scientific fraternity, as well as of the American Society for Testing Materials, American Society for Metals, American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, American Iron and Steel Institute, Compressed Gas Manufacturers' Association, AMERICAN WELDING SOCIETY, Army Ordnance Association, Association of Land Grant Colleges and Universities and Newcomen Society. He is the author of many publications on technical and scientific subjects and is in demand as a speaker on engineering and educational themes.

The Morehead medal was presented to Mr. MacQuigg by the Honorable John Motley Morehead, former United States Minister to Sweden, who established the award in 1922 in honor of his father. Mr. Ellsworth L. Mills of Chicago, President of the International Acetylene Association, presided.

Among other distinguished guests, scientists and educators who were present were Dr. C. H. Mathewson, President of the American Institute of Mining and Metallurgical Engineers, Head of the Department of Metallurgy and Metallography, Sheffield Scientific School, Yale University, who spoke on the significance of Mr. MacQuigg's metallurgical contributions to the industry; and Dr. Charles Penrose, Vice-President of the Newcomen Society and Past-President of the Princeton Engineering Association, who spoke on the importance of Mr. MacQuigg's contributions to engineering education.

Previous recipients of the Morehead Medal have included Edmond Fouché, French scientist and developer of the oxyacetylene blowpipe; Nils Gustav Dalén the blind Swedish scientist and Nobel Prize Winner; and the late Father Julius Nieuwland of Notre Dame University, who developed an important type of synthetic rubber from acetylene.

ARC-WELDING PROCEDURES FOR CAST IRON

Much of the confusion and controversy which have surrounded the subject of making repairs on iron castings by electric arc welding is dispelled in a 12-page illustrated booklet, "4 Ways to Salvage, Reclaim and Conserve Iron Castings by Electric Arc Welding," which has just been published by C. E. Phillips & Co., 2750 Poplar St., Detroit 8, Mich.

This treatise opens with a frank discussion on the inherent difficulties which will be encountered in arc welding cast iron, and points out that there is no single welding material or procedure which can be recommended as a universal practice. It is emphasized that the selection of a procedure for a specific application should be based on the requirements of the finished job. Four types of electrodes for use on cast iron are described, and the characteristics and best welding procedures for each are explained. Microphotographs of the deposits made by the various electrodes are used to show the penetration, the grain structure at the fusion zone and the grain structure of the deposit. Of particular interest to many the foundries and machine shops is the discussion of the Phillips "600" nonferrous electrode which produces deposits of the color of cast iron, and which can be machined through the line of fusion.

LINCOLN DETROIT REPRESENTATIVE

The Lincoln Electric Co., Cleveland, Ohio, announces the appointment of B. J. Brugge as welding engineer in the Detroit, Mich., office.

Mr. Brugge, who has been associated with Lincoln since 1931, has served in the Los Angeles, Calif., and Houston, Texas, offices and, until his transfer to Detroit, has been located in Washington, D. C.

He is a graduate of Purdue University and began his career in arc welding with two years in Lincoln Research Laboratories. In 1935 he was granted a leave of absence to assist in the application of electric welding in the Near East. Serving in the capacity of welding superintendent for the Anglo-Iranian Oil Co., he spent two years at Iran, Persia, supervising welding operations in the construction of refineries and pipe lines.

Following his work in Persian oil fields, Brugge spent four months in the British Isles as welding consulting engineer for British and Scottish firms.

During the past two years, Mr. Brugge redesigned and constructed the Army's first all-welded medium tank at Rock Island Arsenal and helped develop armor plate welding working with the Army Ordnance at the Aberdeen Proving Grounds. He has also assisted the Navy and Maritime Commission with consulting services on shipwelding.

In his new position Mr. Brugge will be engaged in welding engineering work in Detroit where his wide experience in all phases of arc welding will be available to firms in that area for assisting them in the design and fabrication of both present and postwar products.

G-E WOMEN RIVAL MEN IN PRODUCTION IDEAS

Women war workers as well as men turned in top production ideas during 1943 at General Electric plants, and were well represented in the leading awards, the company announced recently. The year's awards for accepted manufacturing suggestions were 47% above the previous year's all-time G-E high.

Women employees, many of them new in industry, added to the total of ideas. During 1943 the company accepted 23,841 as against 16,204 for 1942.

Raymond R. Stoller received $1100—the largest award ever made at the Fort Wayne, Ind., plant—for a suggestion which saves vital supercharger parts. Sometimes during drilling a bit becomes lodged in a part, so he suggested welding a rod to the bit and pulling it out by the rod, thus saving the part.